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FISHERY RESEARCH

University of Idaho

FISH HABITAT ASSOCIATIONS OF THE PEND OREILLE RIVER, IDAHO

Project F-73-R-15
Subproject VI, Study VII

by

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and

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JOB COMPLETION REPORT

State of: **Idaho**

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Title: **Fish Habitat Associations of the Pend Oreille River, Idaho**

Subproject No.: **VI**

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ABSTRACT

The Pend Oreille River, in northwestern Idaho, was impounded in 1952 by Albeni Falls Dam located 44 km downstream of the outlet of Pend Oreille Lake, Idaho. Poor fishing success and limited knowledge of the Pend Oreille River led to a study in 1991 and 1992 to evaluate the fish community, physico-chemical and biologic parameters to provide information for the development of a management plan.

The Pend Oreille River is meso-oligotrophic with annual water temperatures ranging from 0 to 24.5°C. The river may stratify in years of low flow. Substrates are dominated by silt and sand, and velocities generally remain < 30 cm/s, except downstream of Priest River where they may exceed 70 cm/s. Velocities of sloughs are usually zero.

Zooplankton, benthos and aquatic macrophytes were evaluated to provide information on the biological characteristics of the Pend Oreille River. Average zooplankton densities are about 40 organisms/L with sloughs having the highest. Average zooplankton size during August was 0.83 mm, larger than the size considered indicative of intense zooplankton feeding. The benthic community was dominated by chironomids and oligochaetes, although biomass of chironomids and ephemerids was highest. Submerged aquatic macrophytes occupy 14% of the surface area of Pend Oreille River. Aquatic macrophytes are generally distributed in depths > 3 m as annual drawdown exposes the vegetation to freezing and desiccation. The highest aquatic macrophyte densities (131 g/m^2) were found in sloughs where depths were > 3 m. Box Canyon Reservoir, located immediately downstream of Albeni Falls Dam, has aquatic macrophyte densities over five times what we found in the Pend Oreille River. High densities in Box Canyon Reservoir, Washington are a result of the lack of drawdown in Box Canyon Reservoir and establishment of Eurasian milfoil Myriophylum spicatum spicatum.

Over 50,000 fish representing 24 species were sampled in Pend Oreille River, Idaho during the two year study. Yellow perch Perca flavescens, peamouth Mvlocheilus caurinus and northern squawfish Ptychocheilus oregonensis were the more abundant fishes in Pend Oreille River as they represented 64.1% and 59.4% of the catch in 1991 and 1992. All trout species combined represented 1.9% (1991) and 0.6% (1992) of the catch. Largemouth bass Micropterus salmoides ranged from 1.2% in 1991 to 3.3% in 1992 of the total fish community, while black crappie Pomoxis nigromaculatus represented 1.2% in both years.

Largemouth bass and black crappie were found in highest abundance in sloughs which had zero velocities, silty bottoms and vegetation. Rainbow trout Oncorhynchus mykiss and cutthroat trout O. clarki selected littoral habitats along the main river channel where average substrate size was < 15 mm.

Food habits of the more abundant fishes in the Pend Oreille River, Idaho showed low overlap. Yellow perch showed preferences for insects, fish and zooplankton. Northern squawfish fed predominantly on fish and crayfish, while peamouth fed almost exclusively on insects. Diet overlaps were high between largemouth bass, black crappie, brown trout Salmo trutta, yellow perch > 200 mm and northern squawfish. Fish was a large portion of their diet and prey fishes in Pend Oreille River are not limiting.

Growth of game fishes was good in the Pend Oreille River. Growth of yellow perch was typical for this geographical area. Largemouth bass, black crappie and brown trout all experienced higher growth increments than other stocks in the northwest. All three species are low in abundance and feed on the abundant prey fishes which explains, in part, the high growth rates.

Annual mortalities of yellow perch, largemouth bass and black crappie all exceeded 60%. A high proportion of the mortality was natural as fishing pressure is low. High mortalities are probably a result of severe winters coupled with limited overwintering habitat, primarily a result of the 3.5 m drawdown.

Comparison of catch rates of fishes between Pend Oreille River, Idaho and Box Canyon Reservoir indicates drawdown has negative effects on centrarchid fishes (largemouth bass, black crappie and pumpkinseed Lepomis gibbosus). Low catch rates of centrarchid fishes in sloughs during lowpool in the Pend Oreille River, Idaho suggests drawdown has forced fishes into the main river. Summer habitat in the Pend Oreille River is suitable for centrarchids, however, overwintering habitat appears limited as approximately 1% of the habitat is suitable for overwintering centrarchids. If drawdown levels were limited to 2 m (lake elevation 2,056), overwintering habitat for centrarchids would increase 7.5 fold.

Introductions of fishes may be one alternative to improving the sports fishery in the Pend Oreille River. Habitat was found not suitable for sustaining populations of northern pike Esox lucius, and white sturgeon Acipenser transmontanus in the Pend Oreille River. Suitable habitat for smallmouth bass Micropterus dolomieui along the rocky shorelines is limited, although with their introduction some improvement to the fishery could occur. Introductions of channel catfish Ictalurus punctatus may also contribute to the fishery in Pend Oreille River, but under current water management overwintering habitat would be inadequate. Walleye Stizostedion vitreum vitreum introductions might be successful in Pend Oreille River, although they are not recommended because of the high potential to impact Pend Oreille Lake fisheries.

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INTRODUCTION

Prior to 1952, the Pend Oreille River was considered a good cutthroat trout Oncorhynchus clarki fishery (Horner 1989). Rainbow trout O. mykiss, bull trout Salvelinus confluentus and mountain whitefish Prosopium williamsoni were commonly caught in the system. The historical river channel consisted of deep holes and runs with cobble and gravel substrate. These substrates provided spawning habitat for salmonids, and numerous springs and creeks provided cool water temperatures during warm months (John Coil, local resident, personal communication).

Albeni Falls Dam, Idaho was built in 1952 by the U.S. Army Corps of Engineers. Operational procedures require annual water level fluctuations of 3.5 m to maximize hydroelectric power and provide flood control (Dice 1983). During construction trees, shrubs and pilings were cut and removed below high-pool level and banks were sloped to prevent excessive debris from entering the water during flow changes. Absence of vegetation and water level fluctuations led to increased erosion and deposition of silt in gravel bars. Drawdowns exposed littoral zones to erosion and desiccation and dewatered holding and spawning areas for many fishes (Horner 1989).

Dam operations and other developmental activities changed the physico-chemical environment and aquatic biota in the Pend Oreille River. Access to tributaries was restricted from improperly placed culverts, whereas land-use practices degraded spawning and rearing habitat for salmonids in accessible tributaries (Horner 1989). During highpool, increased surface area and retention time of water led to higher temperatures not suitable for salmonids. As a result, unfavorable habitat conditions in the Pend Oreille River have restricted the abundance of salmonids and desired warm water species such as largemouth bass Micropterus salmoides and black crappie Pomoxis nigromaculatus.

Stocking programs of various species of salmonids have proved unsuccessful. An evaluation of catchable trout in 1984-1985 revealed a 6% return to the creel which led to a cessation of stocking catchable trout in the river (Horner et al. 1987). A cursory survey by Idaho Department of Fish and Game in 1986 indicated the fish community was dominated by northern squawfish Ptychocheilus oregonensis, other cyprinid fishes and yellow perch Perca flavescens (Horner et al. 1987). Currently, the Pend Oreille River, Idaho offers limited fishing during the spring for salmonids and largemouth bass. Conservation officers report that few people fish the Pend Oreille River, and catches of salmonids and centrarchid fishes are rare (Horner 1989).

While extensive research has been conducted on Pend Oreille Lake, Idaho (Stross 1953; Irving 1986; Rieman 1976; Bowler 1978;), little is known about the Pend Oreille River. The purpose of this study is to aid in the development of future management plans by determining fish habitat associations and limitations in the Pend Oreille River system.

OBJECTIVES

1. To identify and evaluate existing physico-chemical and biotic habitat conditions in the Pend Oreille River, Idaho;

2. To assess the relative abundance of fishes and determine fish habitat associations as related to drawdown in the Pend Oreille River, Idaho;

3. To assess food habits of fishes in the Pend Oreille River, Idaho;

4. To determine and compare age, growth and mortality of selected game fishes in the Pend Oreille River, Idaho with other systems of the same latitude;

5. To determine the effects of drawdown on fish populations in the Pend Oreille River, Idaho; and

6. To evaluate potential introduction of fishes into the Pend Oreille River, Idaho.

STUDY AREA

The Pend Oreille River is located in northern Idaho beginning at the outlet of Pend Oreille Lake. The Pend Oreille River is a large system with a drainage area of 62,678 km^2 (24,200 mi^2) and flows ranging from 616.6 (11,200 cfs; average monthly minimum) to 2,044 m^3 (73,000 cfs; average monthly maximum).

We studied a 3,887 ha section of the Pend Oreille River that extends 44.25 km from Albeni Falls Dam upstream to Long Bridge near Sandpoint, Idaho (Figure 1). About 161 km of shoreline, including sloughs and islands, has gentle to moderate slope consisting of mostly fine sediments (< 4 mm), while about 16 km of shoreline is rocky and consists of rip rap. The river has an average depth of 7.1 m, a maximum depth of 48.5 m, a maximum width of 3.2 km, and is annually drawn down 3.5 m. Drawdown starts in mid-September and reaches lowpool (625.1 m lake elevation) by mid-November. Water levels rise in mid-April and reach highpool (628.65 m lake elevation) by mid-June (Dice 1983).

The study site was divided into six strata, three littoral and three pelagic, to insure all habitat types of the river were adequately sampled (Figure 1; Appendix Table 1). Littoral strata were divided by substrate size and orientation to the main river channel. Pelagic strata were divided according to maximum river depth and average width. Each stratum was partitioned into 1.0 km sections. During each sampling period, two or three sections within each stratum were randomly selected for sampling.

PEND OREILLE RIVER STUDY SITE

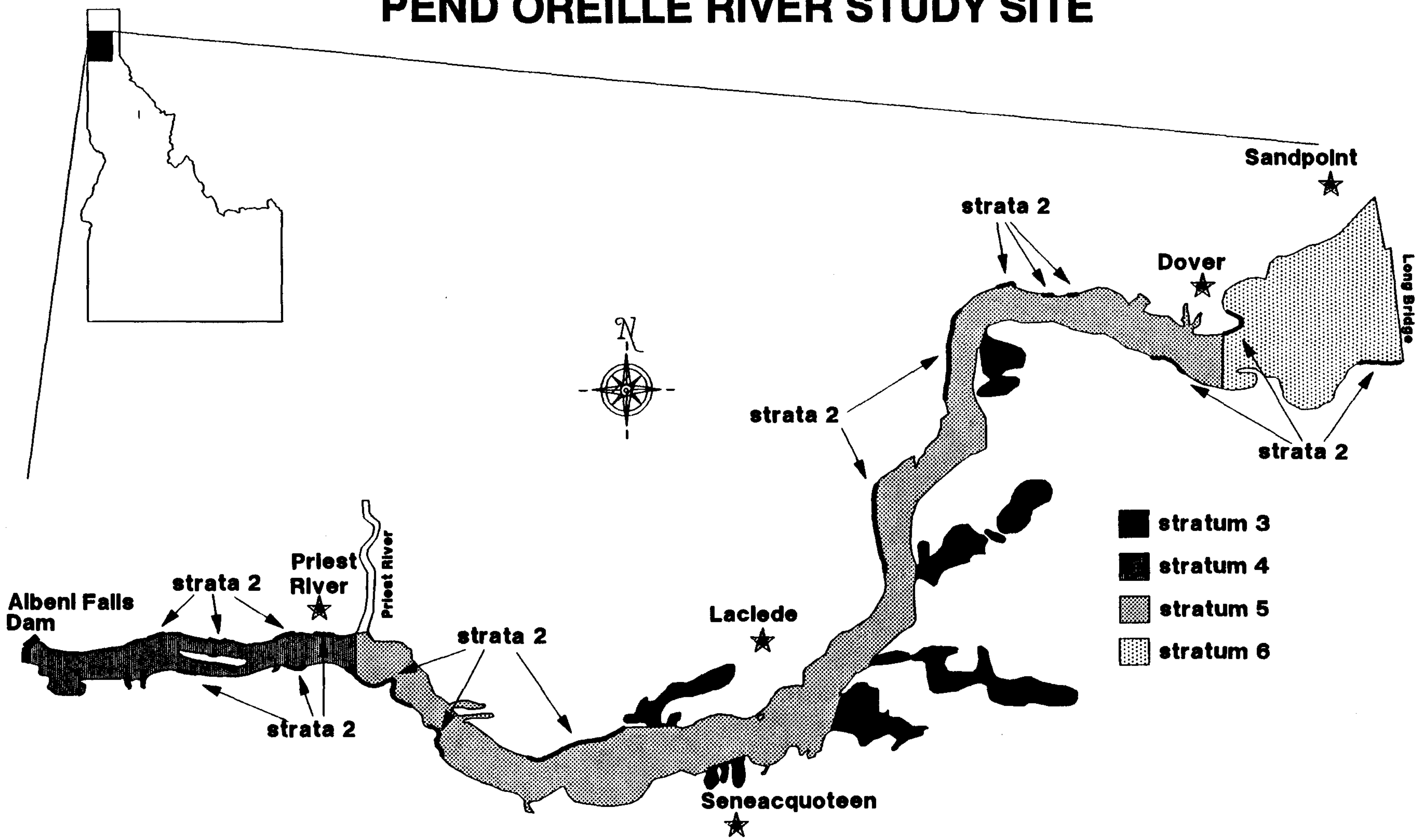


Figure 1. Pend Oreille River study area with indicated strata. All non labeled shoreline along the main river channel is stratum 1.

Objective 1. To identify and evaluate existing physico-chemical and biotic habitat conditions in the Pend Oreille River, Idaho.

METHODS

Phvsico-Chemical Conditions

Daily average river temperatures for the entire study period (1990-1992) were obtained from the U.S. Army Corps of Engineers through readings at Albeni Falls Dam. Slough water temperatures were collected from June 6 to October 29, 1991 at a depth of 1 m with maximum/minimum thermometers. Weekly average slough temperatures were determined during this period.

Temperature recordings enabled us to calculate the length of the growing season for centrarchids, including largemouth bass and black crappie (number of days > 10°C), and selected salmonids, including cutthroat trout, rainbow trout and brown trout Salmo trutta (number of days > 4°C and < 21°C). The duration of the growing season was determined for centrarchids by calculating the number of degree days > 10°C. Degree days were calculated by summing the degrees > 10°C each day for the entire calendar year.

Temperature profiles were collected at several of the rivers deepest sections (> 30 m/100 ft) during July and August to determine if stratification occurred. If present, stratification could provide sanctuaries of cool temperatures for salmonids during warm months.

Dissolved oxygen profiles were recorded at the same sites where temperature profiles were collected. Dissolved oxygen concentrations < 5 mg/L indicate limited conditions for many game fishes (Everhart and Youngs 1981; Cobble 1982). Dissolved oxygen was measured in the sloughs and weed-filled bays.

Conductivity, pH and transparency (secchi disk) were measured with respective meters in the field and phosphorus was analyzed in the laboratory. These readings were used to determine the trophic status of the system (oligotrophic, mesotrophic and eutrophic) which indicates productivity. Eutrophic systems (highly productive) tend to have phosphorus concentrations > 24 ug/L, secchi readings < 2 mm and pH readings > 8 (Goldman and Horne 1983; Wetzel 1983).

Daily water levels (lake elevation) were obtained for 1991 and 1992 from the U.S. Army Corps of Engineers. Water level fluctuations can be detrimental to the success of spawning fishes. Mitchell (1982) found that water increments of 69 cm/d can cause nest abandonment of largemouth bass, whereas increments of 6.1 cm/d can result in strong year classes.

A map containing river depths, substrate types and velocities was developed to quantify available fish habitat. River contours were developed from extensive depth findings and by data obtained from U.S. Geological Survey. Substrate composition was determined through dredge sampling at 1 km transects with four samples collected across the river. Substrate samples were sifted through various sized screens to determine size composition. Areas that could not be dredged due to large substrate size were observed underwater with SCUBA. During lowpool, 3.5 m of shoreline was exposed allowing visual inspection of the substrate. Water velocities were determined during August and late November at 1 km transects with four to six readings collected across the river. Velocities were recorded 1 m below the surface and 1 m above the bottom. Velocities were also collected from back water areas to determine if zero velocities were present.

Biotic Conditions

The zooplankton and benthic invertebrate communities were sampled during June 1991 through August 1991. Samples were collected within each of the six strata (Figure 1; Appendix Table 1) when conditions permitted. Two or three sites at each stratum were randomly selected for sampling. Zooplankton was sampled with a 25-L Shindler box about 1 m below the surface, whereas benthos was sampled with a Ponar petite dredge (225 cm^2). Five sample hauls at each site for both zooplankton and benthos were collected, combined and preserved in 70% ethyl alcohol with 3% glycerin to prevent shrinking.

Zooplankton densities, relative species abundance and size were determined spatially and temporally. Standard dilution and subsampling techniques were used to enumerate zooplankton to genus (Edmonson and Winberg 1971). Zooplankton lengths from the most abundant species were determined by measuring 20-30 individuals under a dissecting microscope equipped with an ocular micrometer. Average lengths were calculated to determine the size structure of the zooplankton community. Average zooplankton sizes < 0.8 mm may indicate that excessive cropping is occurring (Mills et al. 1987).

Benthic invertebrates were identified to family. Densities were determined by calculating number of specimens sampled per unit area, and biomass was determined for each stratum by multiplying the average weight of each family by their densities.

Aquatic macrophytes were randomly sampled at each stratum in early August during peak plant growth. Three dredge hauls at each sampling site were used to collect macrophytes. Samples were immediately frozen and later thawed to determine species composition and biomass (dry weights). Distribution of aquatic vegetation was determined by visually identifying concentrations from a boat during calm sunny days. Additional visual observations occurred during peak plant growth and during lowpool. Aquatic macrophyte composition, biomass and distribution were assessed and related to fish distribution to determine their association with fish communities.

RESULTS

Phvsico-Chemical Conditions

Temperature and Dissolved Oxygen

The average water temperature of Pend Oreille River, Idaho was 10.2°C in 1991 and 11.2°C in 1992. Water temperatures were > 21°C for 39 days in 1991 and 48 days were > 21°C during 1992. Water temperatures were < 4°C for 98 days during 1991 compared to 88 during 1992.

Water temperatures on the Pend Oreille River during 1991 and 1992 were lowest during January (0°C) (Figure 2). Temperatures began increasing during February 1991 and during March in 1992. The highest daily average temperature (22.5°C) was recorded during late August for both 1991 and 1992. Slough temperatures were generally higher than main river temperatures during 1991 with the highest temperatures (24.5°C) recorded in mid-August. Slough temperatures could not be measured before June or after October as a result of fluctuating water levels. Slough temperatures were not gathered during 1992 as thermometers were vandalized.

Temperature and dissolved oxygen profiles collected in Pend Oreille River during 1991 indicated stratification did not occur as temperatures dropped 0.5 and 1.0°C from top to bottom in July and August (Figure 3). During 1992, stratification was present in the Pend Oreille River as temperatures decreased from 22.2 to 17.6°C from top to bottom. Dissolved oxygen concentrations remained > 7 mg/L (Figure 3).

The length of the growing season for centrarchid fishes (number of days > 10°C) was 161 days in 1991 and 185 days in 1992. During 1991, 10°C was reached by mid-May and continued until late October, and during 1992 10°C was reached in late April and continued until early November (Figure 2). The strength of the growing season was 1,134 degree days during 1991 and 1,146 degree days in 1992.

The length of the growing season (number of days > 4°C and < 21°C) for selected salmonids (rainbow, cutthroat and brown trout) was 228 days in 1991 and 278 days in 1992. Although days were generally warmer in 1992, the stratification of the river provided a thermal refuge that increased the length of the growing season for salmonids. Temperatures < 4°C were recorded from the beginning of December through March (Figure 2).

Conductivity, pH, Transparency and Phosphorus

Conductivity, pH, transparency and phosphorus measurements were used to assess the productivity and trophic status of the system. Conductivity recordings were generally lowest during June 1991 and highest during October 1991, although no distinct patterns were found between strata (Table 1).

1991 and 1992 Temperature Readings

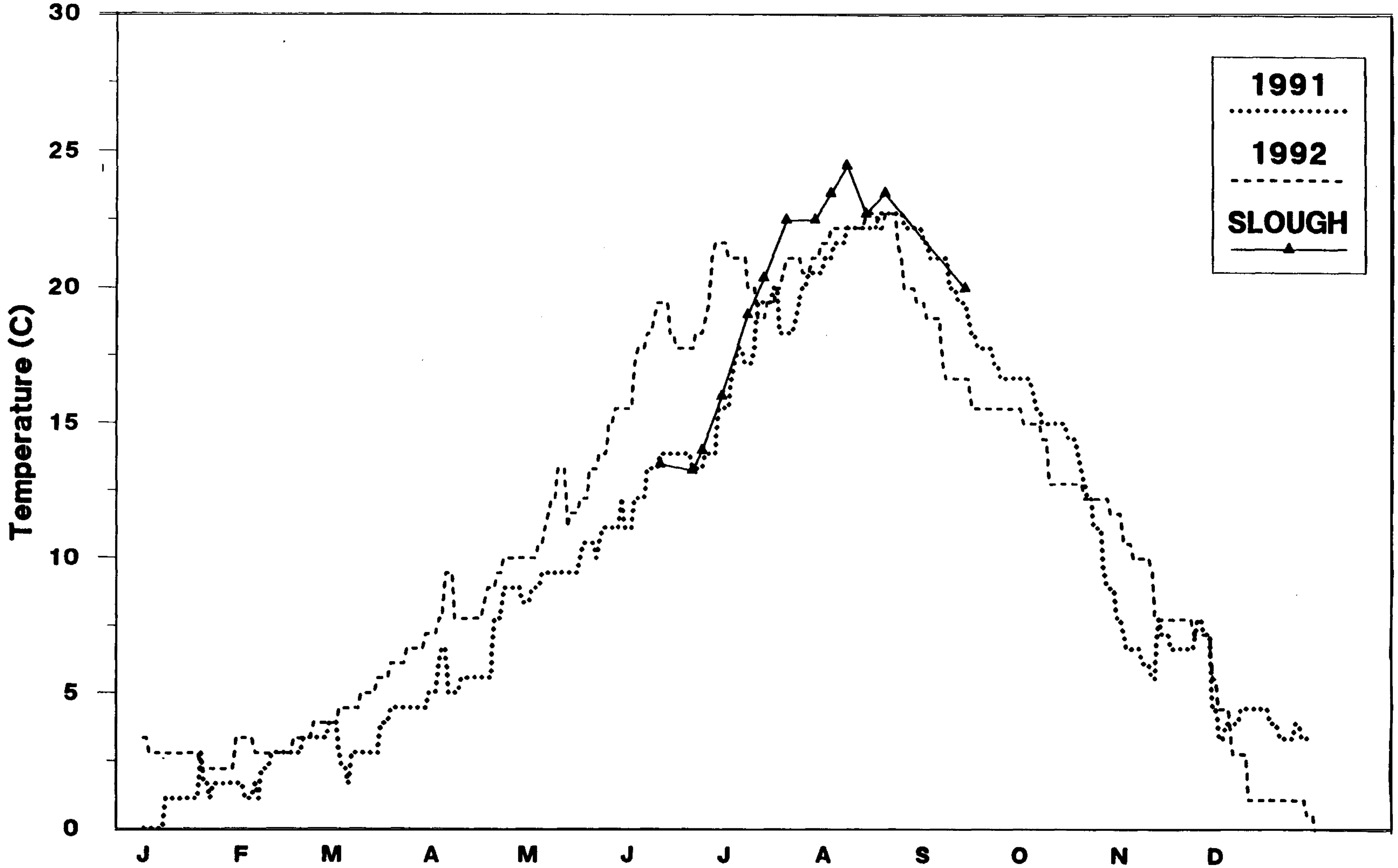


Figure 2. Daily average river temperatures collected during 1991 and 1992 at Albeni Falls Dam. Average slough temperatures were collected in Riley Creek Slough during 1991 with a maximum/minimum thermometer.

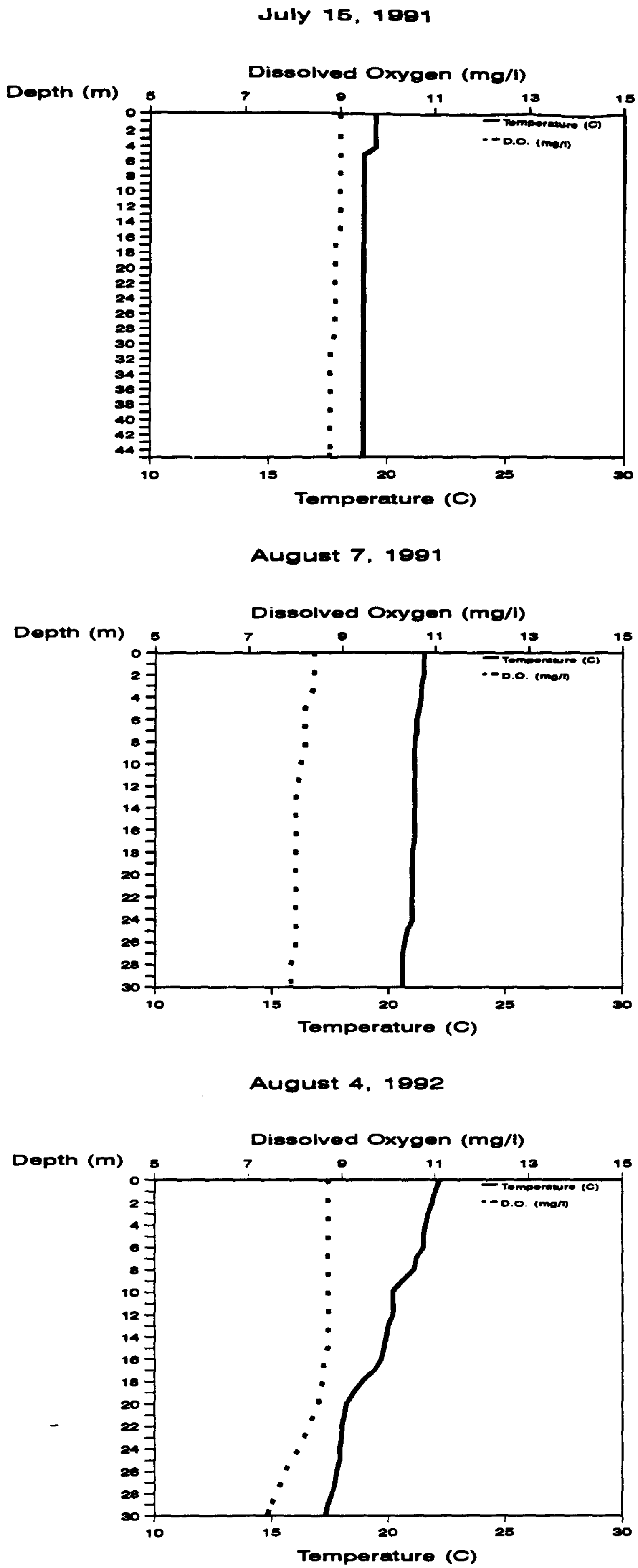


Figure 3. Temperature and dissolved oxygen profiles taken during 1991 and 1992 from river mile 102.3 of the Pend Oreille River, Idaho.

Table 1. Average conductivity, pH and secchi readings from each stratum of the Pend Oreille River, Idaho.

CONDUCTIVITY (umhos)

	STRATA					
DATE	1	2	3	4	5	6
6-23-91	118	99	116			135
7-15-91	135	133	131	131	132	141
8-17-91	137	135	121	135	132	142
10-20-91	153	152	155	159	152	150
3-17-92	140	136	75		140	138

pH

	STRATA					
DATE	1	2	3	4	5	6
6-23-91	8.59	8.46	8.29			827
7-15-91						
8-17-91						
10-20-91	8.56	8.57			8.57	8.5
3-17-92	7.23	7.26	6.91		7.25	7.25

SECCHI READINGS (m)
(Transparency)

	STRATA					
DATE	1	2	3	4	5	6
6-6-91	1.24	1.67	0.8			2.08
6-23-91	2.18	2.5	1.35			2.9
7-15-91	3.06	3.39	2.93	2.83	2.82	4.01
8-17-91	3.67	4.05	2.75	3.44	4.38	4
10-20-91	4.31	4.44	0.82	3	4.44	4+
3-17-92	2.25	2.25	0.88		3.45	3.5

TOTAL PHOSPHOROUS (ug PO4/l)

Date	slough	main river
6-7-92	15.9	8.3
8-1-92	4.6	2.4

Conductivity ranged from 75 umhos in March 1992 to 159 umhos in October 1991 and was inversely related to flows. Readings of pH during June and October 1991 were generally 8.5 and March 1992 readings were around 7.24. No distinct patterns of pH were noticed between strata (Table 1).

Transparency (secchi readings) generally increased throughout the year with the lowest transparencies (0.8 m) recorded in early June 1991 and the highest (4.44 m) recorded in October 1991. Sloughs (stratum 3) consistently had the lowest (0.8) transparencies (Table 1).

Total phosphorus (PO_4) decreased from June to August 1992 and the highest concentrations occurred in the sloughs (Table 1). Total phosphorus concentrations were 15.9 mg/L in Morton Slough on June 7, 1992 and 4.6 mg/L on August 1, 1992. Phosphorus concentrations in the main river channel were 8.3 mg/L during June 7 and 2.4 mg/L during August 1, 1992.

Water Level Fluctuations

Water level fluctuations in Pend Oreille River, Idaho was similar between 1991 and 1992, as highpool was reached during mid- to late June and lasted until early September (Figure 4). Water levels reached lowpool during mid-November and were maintained until the beginning of April.

Initial nest building of largemouth bass generally occurs when water temperature reach 16°C with spawning occurring around 17°C. Black crappie have similar patterns as spawning activity begins at 14.4 to 17.8°C (Scott and Crossman 1973; Carlander 1977). Water temperatures in the Pend Oreille River reached 16°C on July 3, 1991 and June 2, 1992. Highpool was reached on June 24, 1991 and June 15, 1992. Water levels continued to rise in 1992 after the river reached appropriate temperatures for spawning. From June 2-15, 1992, water levels rose an average of 8 cm/d.

Fall spawning fish, such as kokanee and brown trout, spawn at temperatures near 7°C (Scott and Crossman 1973; Carlander 1977). Spawning has been observed in early November for brown trout and mid-November for shoreline spawning kokanee. Lowpool was reached on November 25, 1991 and November 16, 1992. Water levels decreased 0.89 m from November 1 to November 25, 1991 for an average of 3.7 cm/d. During 1992, water levels dropped 0.95 m from November 1 to November 16 for an average of 6.4 cm/d.

Substrate Composition

Substrate of the Pend Oreille River was divided into five size categories; fines (< 1 mm), sand (1-4 mm), gravel (4-75 mm), cobble (75-300 mm) and bolder to bedrock (> 300 mm). Fines are the dominant substrate on the Pend Oreille River and they cover 2,636 ha, or approximately 66.9% of the river bottom. Fine sediments are found in wide portions of the river and in all sloughs (Figure 5). Sand covers 769 ha (19.5%), gravel 424 ha (10.8%), cobble 49 ha (1.2%) and bolder

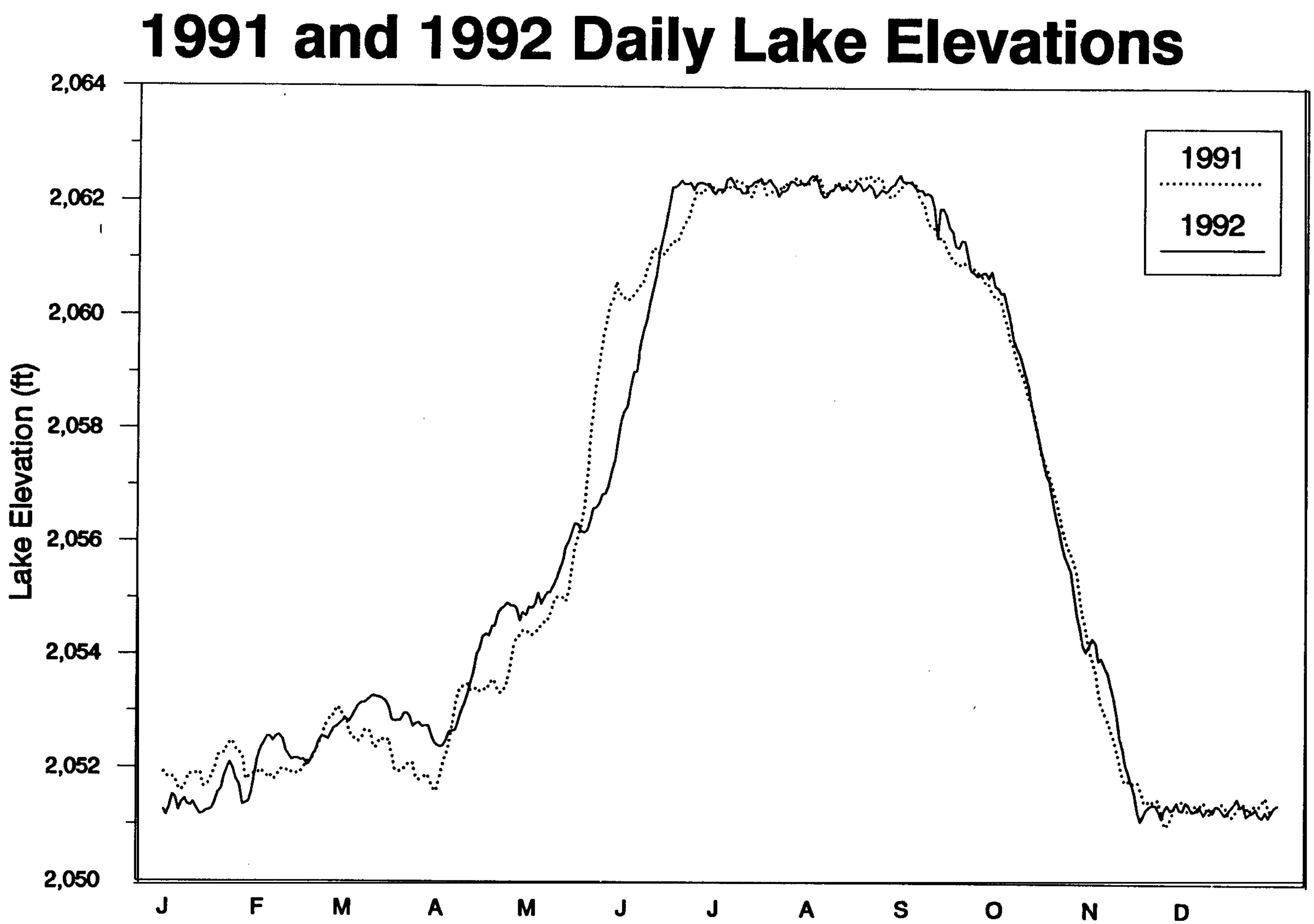


Figure 4. Daily water elevations recorded at midnight on Pend Oreille Lake during 1991 and 1992.

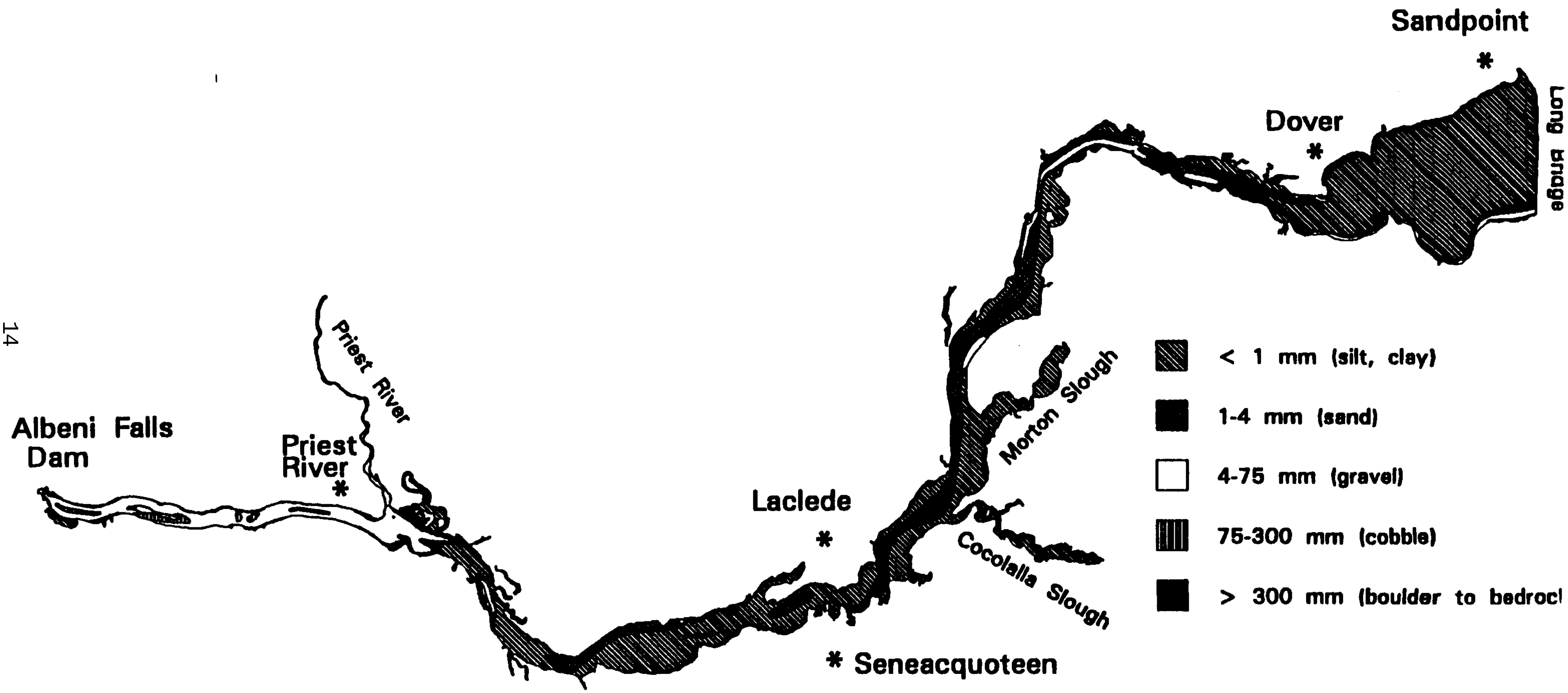


Figure 5. Substrate composition of Pend Oreille River, Idaho.

to bedrock 62 ha (1.6%). Most areas of bolder to bedrock are located along roads or railroad tracks where rip-rap has been dumped into the river to prevent erosion. Below Priest River the substrate is predominantly large gravel and cobble.

River Velocities

Velocities were collected in Pend Oreille River during July 29-31, 1992 and November 24-26, 1992 at 1 m below the surface and 1 m above the bottom (Figure 6). The highest surface velocities during July were recorded below Priest River and in narrow portions of the river (18-30 cm/s). The slowest velocities (0-9 cm/s) were recorded in the widest portions of the river, especially below Long Bridge. All sloughs had zero velocities.

Velocities collected 1 m above the bottom were slower than those collected 1 m below the surface (Figure 7). Velocities measured from the bottom generally ranged from 0 to 6 cm/s with the highest (9-18 cm/s) collected below Priest River.

During late November, the Pend Oreille River is drawn down 3.5 m causing the water velocity to increase. The highest (60-76 cm/s) subsurface (1 m below the surface) water velocities collected during November 29-31, 1992 were in the narrow portions of the river, especially below Priest River (Figure 8). Velocities collected 1 m above the bottom were similar to those collected 1 m below the surface, although they were slightly lower (Figure 9).

River Depths

The Pend Oreille River has different habitat types, many of which can be distinguished by river depth. The shallowest portion occurs in the widest area between Long Bridge and Dover (stratum 6) with an average depth of 5.4 m (Figure 10). The deepest sections of the river are found between Dover and Priest River (stratum 5) with five areas at depths > 30 m (100 ft). The deepest location on the river is 48.5 m (159 ft) and is located across from Laclede. The average depth between Dover and Priest River is 8.2 m. All sloughs do not have depths > 5 m. Downstream of Priest River (stratum 4), the average depth is 6.4 m with no areas > 15 m deep (Figure 10).

Bioloqical Components

Zooplankton

Zooplankton sampling revealed 15 copepod and cladoceran species (Table 2). Copepods, including nauplius larvae, were the most abundant zooplankton representing 62% of the relative abundance, whereas cladocerans represented 31%.

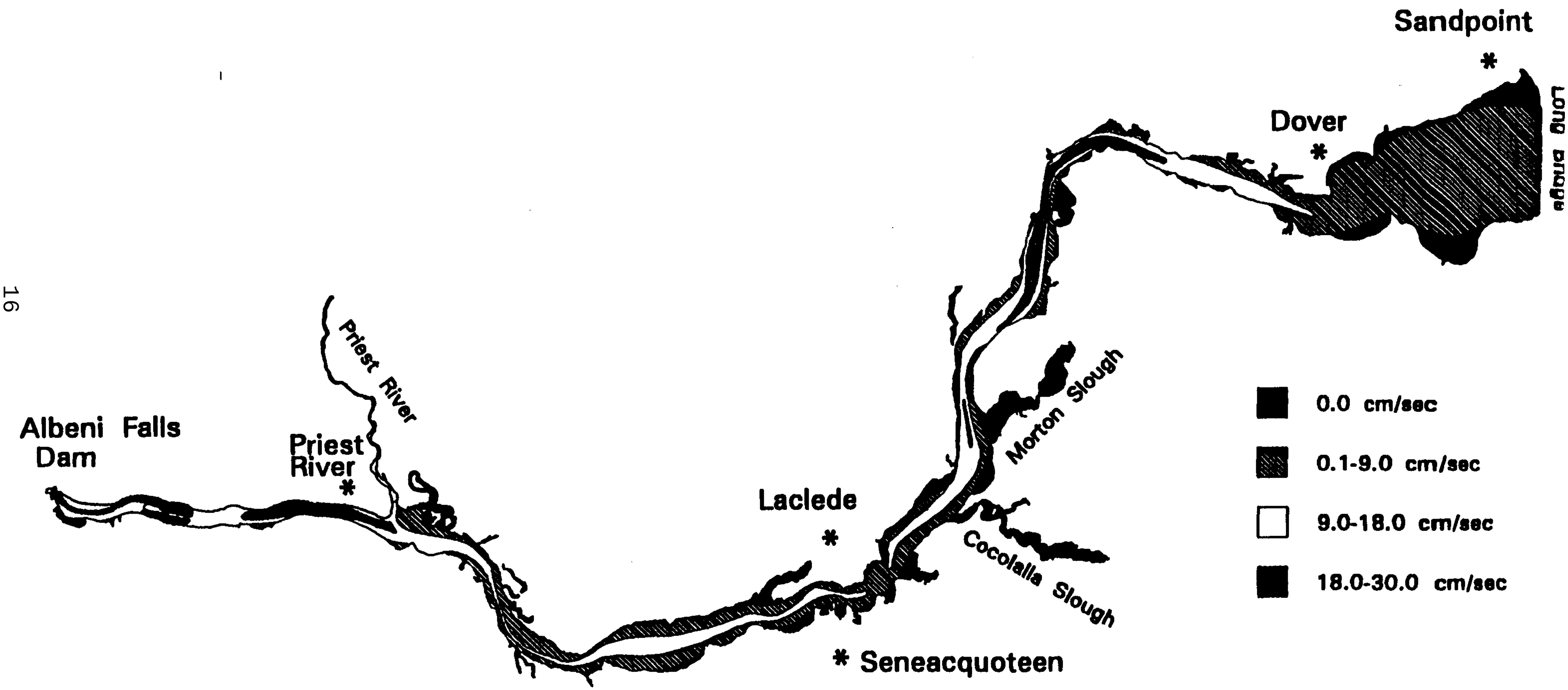


Figure 6. Water velocities collected one meter below the surface during July 1992 on Pend Oreille River, Idaho.

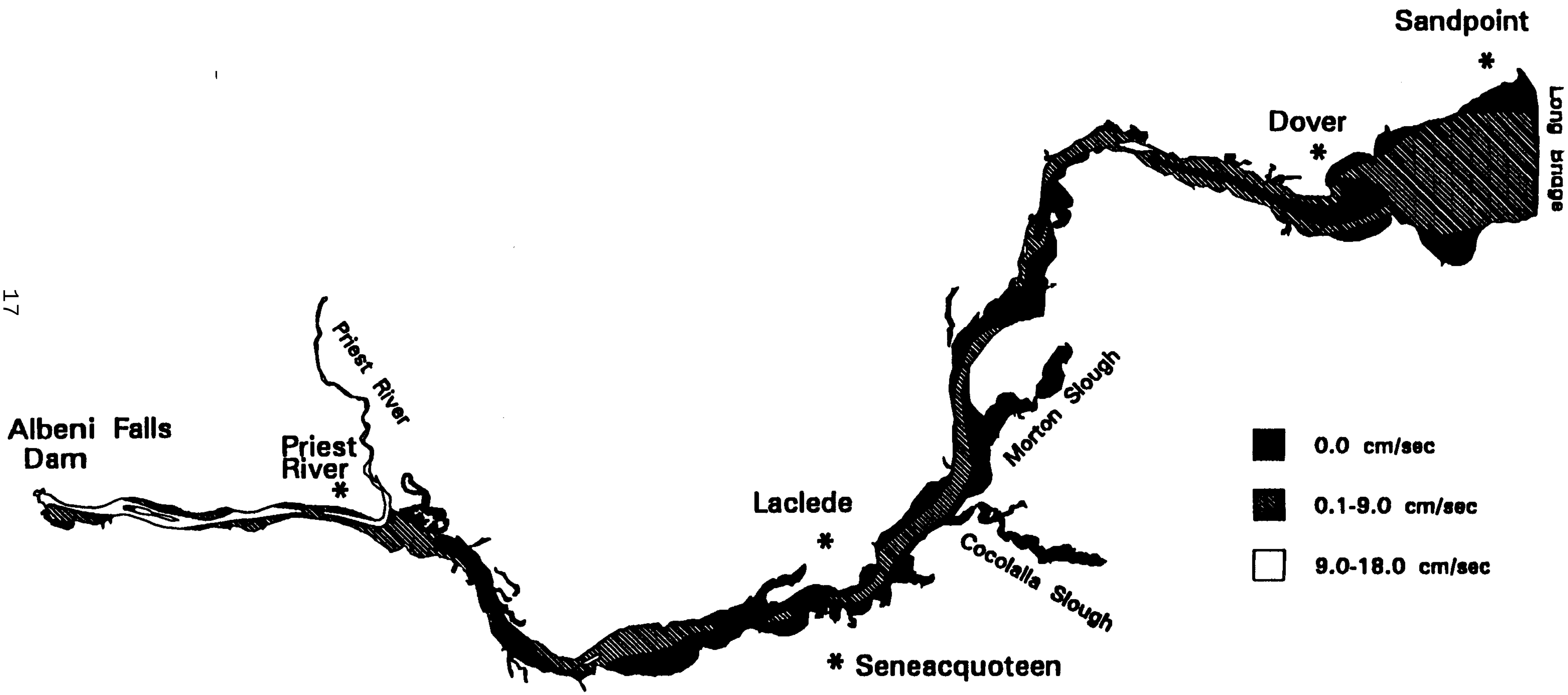


Figure 7. Water velocities collected one meter above the bottom during July 1992 on Pend Oreille River, Idaho.

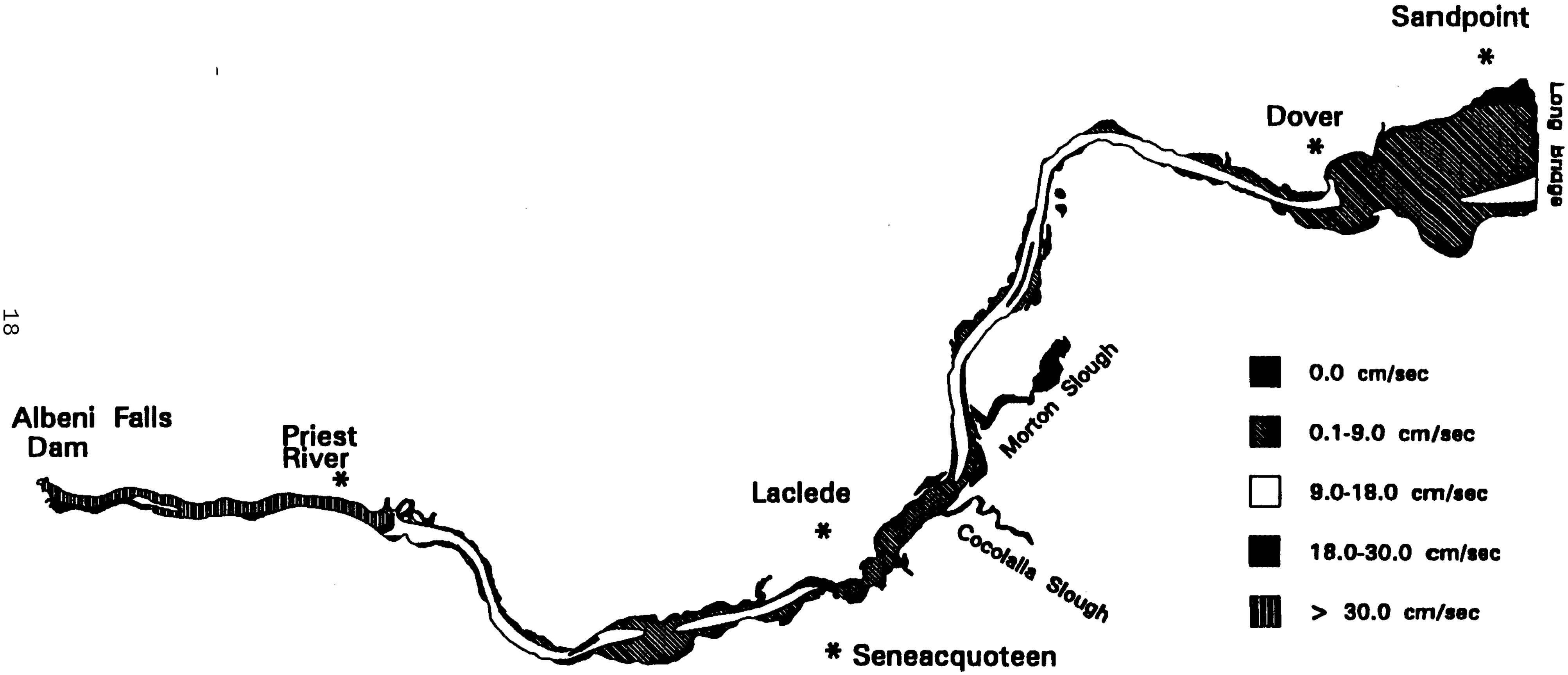


Figure 8. Water velocities collected one meter below the surface during late November 1992 on Pend Oreille River, Idaho.

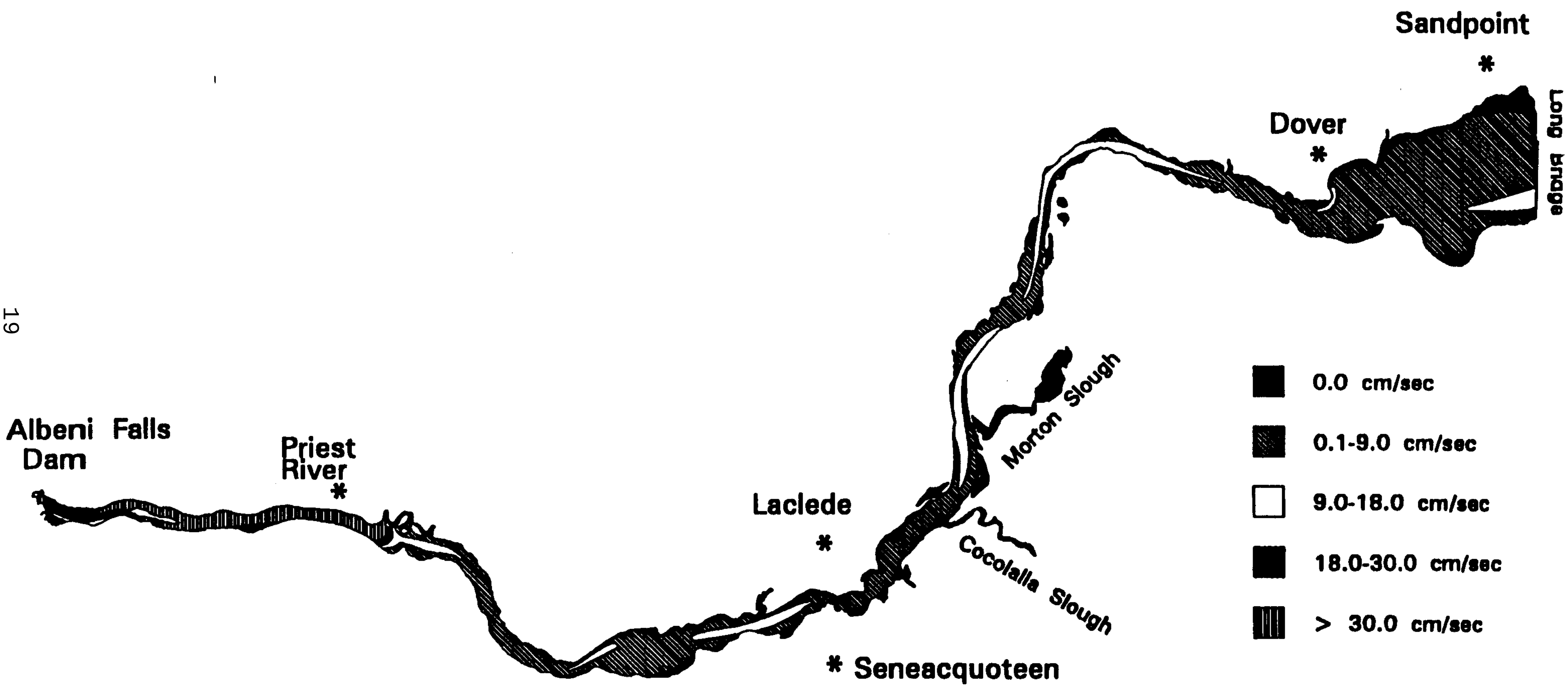


Figure 9. Water velocities collected one meter above bottom during late November 1992 on Pend Oreille River, Idaho.

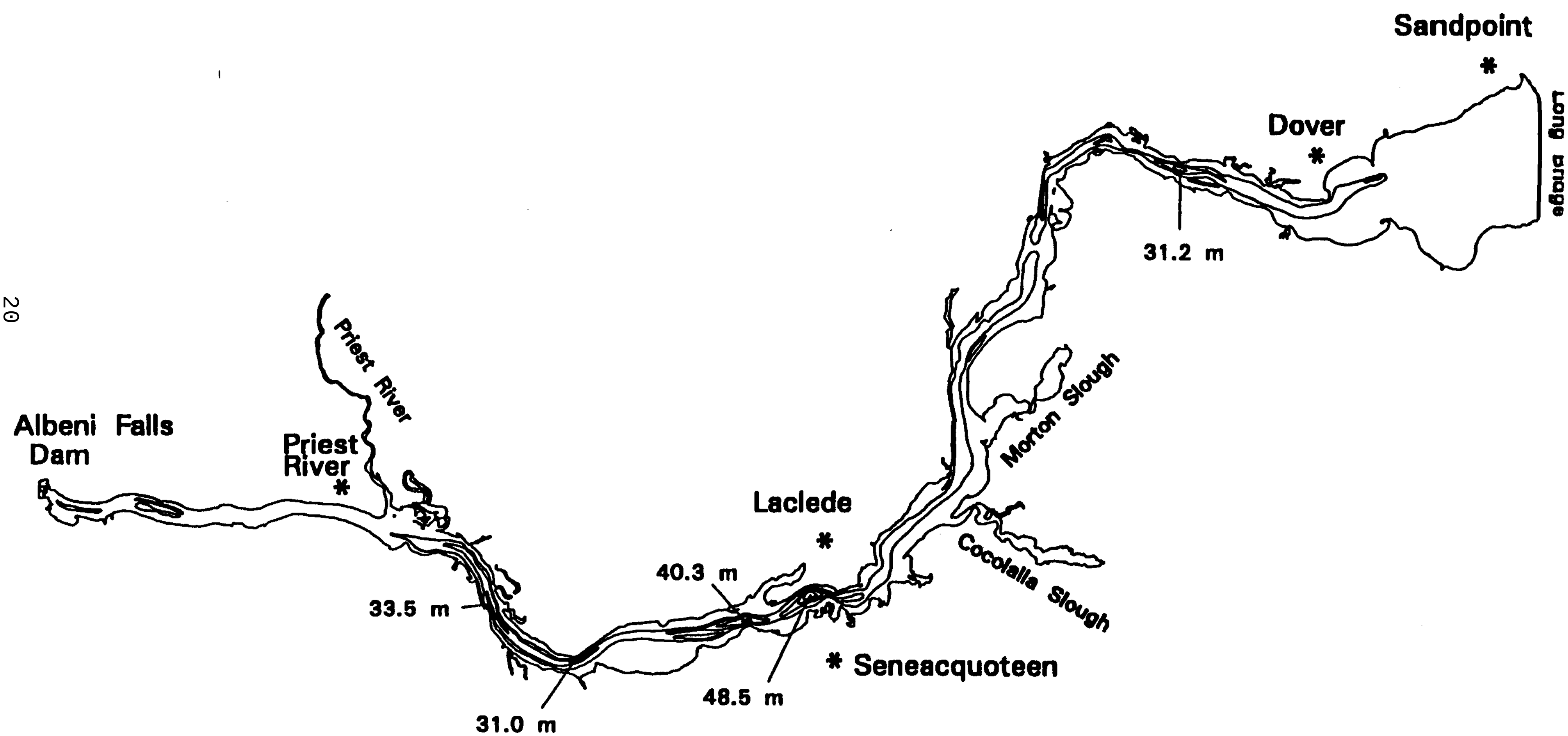


Figure 10. Pend Oreille River, Idaho during highpool with 10 m contour intervals.

Table 2. Zooplankton species observed in the Pend Oreille River, Idaho during 1991.

Phylum Arthropoda
  Class Crustacea
    Subclass Brachiopoda
      Order Cladocera
        Family Bosminidae
          Bosmina longirostris
        Family Chydoridae
          Camptocercus rectirostris
          Chydorus sphaericus
          Eurycercus lamellatus
          Graptoleberis testudinaria
        Family Daphnidae
          Ceriodaphnia quadrangula
          Daphnia galeata mendotae
          Simocephalus serrulatus
          Simocephalus vetulus
        Family Leptodoridae
          Leptodora kindti
        Family Sididae
          Diaphanosoma leuchtenbergianum
          Sida Crystallina
    Subclass Copepoda
      Order Eucopepoda
        Suborder Calanoida
          Family Diaptomidae
            Diaptomus ashlandi
          Family Temoridae
            Epischura nevadensis
        Suborder Cyclopoida
          Family Cyclopoidae
            Cyclops bicuspidatus

Cyclops bicuspidatus, Bosmina longirostris, biaptomus ashlandi, Ceriodaphnia auadranqula, Daphnia galeata mendotae, Diaphanosoma leuchtenbergianum and Chydorus sphaericus comprised 91% of all zooplankton sampled and were the only species analyzed.

Mean zooplankton densities for the Pend Oreille River were 40 organisms/L during July 1991 and August 1991 (Table 3). Sloughs (stratum 3) consistently had the highest densities of zooplankton; in July densities were as high as 87 organisms/L and in August 120 organisms/L. Other strata had fairly consistent densities ranging from 15 to 37 organisms/L. No patterns in abundance were found between pelagic (strata 4, 5 and 6) and littoral waters (strata 1 and 2).

Cyclops bicuspidatus was consistently the most abundant species sampled in each stratum during July 1991 and August 1991 except in stratum 3 (sloughs), where B. longirostris was the most abundant (Figure 11). Stratum 3 also had high densities of C. sphaericus during July and in August and C. quadranqula and D. galeata mendotae were also collected (Figure 11).

Collections of C. bicuspidatus and C. quadranqula indicated higher densities in August 1991 than in July 1991, except in stratum 6 where C. bicuspidatus had slightly higher densities in July (Figure 11). Bosmina longirostris and C. sphaericus exhibited higher densities in July than August, except in stratum 3 where B. longirostris had higher densities in August. Diaptomus ashlandi, D. galeata mendotae and D. leuchtenbergianum densities were similar between July and August.

We found no trends of average lengths of zooplankton between strata during July 1991 or August 1991 (Figure 12). During July C. bicuspidatus, D. ashlandi and C. quadranqula generally had average lengths longer than or similar to 0.8 mm. During August, D. ashlandi, D. craleate mendotae and D. leuchtenbergianum had average lengths > 0.8 mm, whereas C. bicuspidatus and C. quadrangula always averaged < 0.8 mm. Bosmina longirostris and C. sphaericus were the smallest zooplankton ranging from 0.3 to 0.4 mm.

Benthic Macroinvertebrates

Chironomids, oligochaetes, gammarus shrimp and sphaerids (freshwater clams) were the more abundant benthic macroinvertebrates sampled in Pend Oreille River, Idaho (Table 4). Chironomids and oligochaetes represented > 67% of the organisms sampled. Sampling during July 1991 generally had higher densities than in August 1991 and stratum 1 had the highest densities. Stratum 3 (sloughs) had the lowest macroinvertebrate densities and diversities during July and August, except for strata 2 and 5 that could not be effectively sampled by dredge because of rock and gravel substrate. Stratum 3 was dominated by chironomids and oligochaetes that represented > 90% of the samples during July and August.

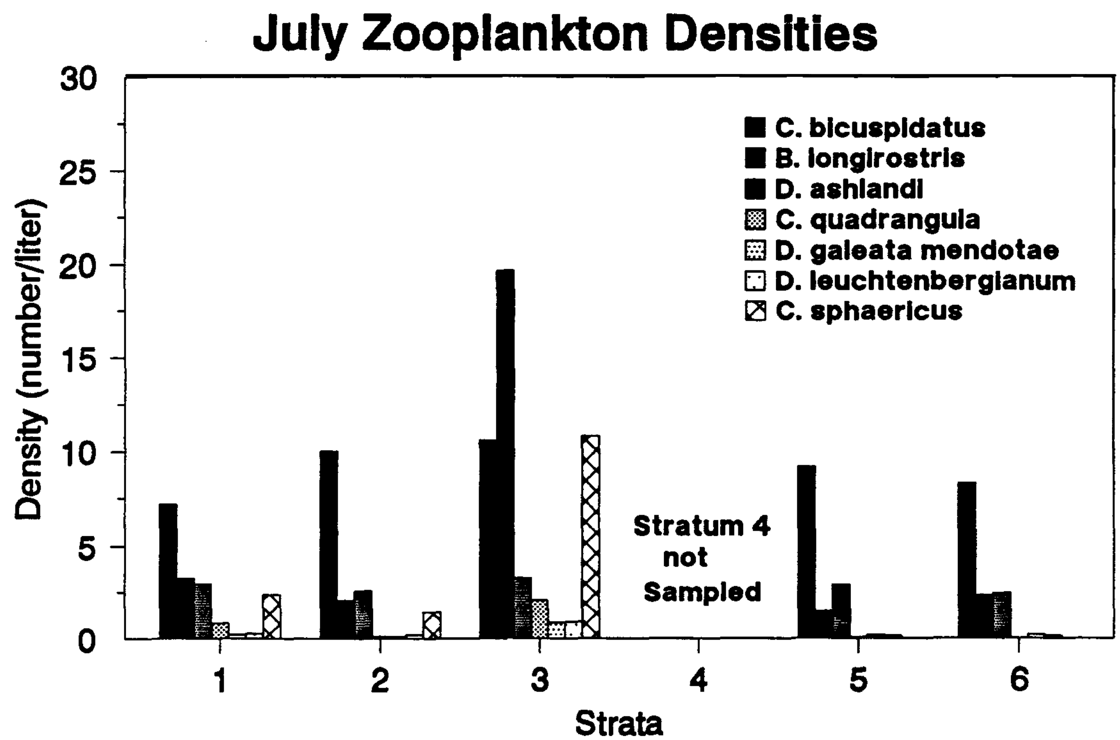
Chironomids, ephemeropterans, sphaerids and oligochaetes were the dominant organisms representing > 84% of the biomass of all samples combined (Table 5). The large size of ephemeropterans, Hexeaenia limbata, accounted for > 20% of the overall biomass even though their densities were low (< 2%). Macroinvertebrate

Table 3. Average zooplankton densities from collections during July 9-10, 1991 and August 5, 1991 at each strata of the Pend Oreille River. Stratum 4 was not sampled from July 9-10.

-- - - --	Average zooplankton denisities (organiams/L) at each statu						Combined Average	Relative Abundance
Genus	1	2	3	4	5	6		
auplius larvae (Copepoda)	7.68	5.42	19.70		8.74	15.14	11.34	28.3
Cyclops bicuspidatus	721	10.01	10.61		9.17	8.29	9.06	22.6
Bosmina *'ongirostris*	3.31	2.05	19.64		1.48	2.34	5.76	14.4
Rotifera	4.99	0.74	16.11		0.42	0.42	4.54	11.3
Chydorus sphaericus	2.37	1.41	10.80		0.00	0.00	2.92	7.3
Diaptomus ashlandi	2.99	2.59	3.30		2.91	2.43	2.84	7.1
Ostracoda (seed shrimp)	2.88	0.08	0.48		0.00	0.13	0.71	1.8
Ceriodaphnia quadrangula	0.85	0.10	2.08		0.06	0.00	0.62	1.5
Graptoleberis testudinaria	1.41	0.00	0.32		0.00	0.13	0.37	0.9
Eurycercus lamellatus	0.83	0.38	0.56		0.00	0.00	0.36	0.9
Diaphanosoma leuchtenbergianum	0.26	0.19	0.91		0.12	0.13	0.32	0.8
Sida crystallina	0.16	0.64	0.56		0.19	0.00	0.31	0.8
Daphnia galeata mendotae	0.19	0.08	0.87		0.18	0.19	0.30	0.8
Leptodora kinditi	0.13	0.39	0.08		0.00	0.13	0.15	0.4
Hydra	0.38	0.00	0.00		0.19	0.10	0.13	0.3
Camptocercus rectirostris	0.26	0.00	0.08		0.00	0.00	0.07	0.2
Epischura nevadensis	0.19	0.00	0.00		0.06	0.06	0.06	02
Ephemeroptera	0.22	0.00	0.08		0.00	0.00	0.06	0.2
Diptera	0.06	0.00	0.24		0.00	0.00	0.06	0.2
Oligochaeta	0.00	0.00	0.20		0.00	0.00	0.04	0.1
Simocephalus vetulus	0.19	0.00	0.00		0.00	0.00	0.04	0.1
Araneae (water spider)	0.00	0.08	0.00		0.00	0.00	0.02	<0.1
Acarina (water mite)	_ 0.06	0.00	0.00		0.00	0.00	0.01	<0.1
TOTAL	36.63	24.17	86.62		23.52	29.47	40.08	100.0

August 5 1991 ,

	Average zooplankton denisities (organisrns/L) at each statu						Combined	Relative Abundance
Genus	1	2	3	4	5	6	Average	
Cyclops *bicuspidatus*	11.30	10.33	2423	17.16	13.76	7.33	14.02	34.9
Nauplius larvae (Copepods)	4.07	4.40	23.82	3.64	4.14	1.88	6.99	17.4
Bosmina *longirostris*	0.44	0.06	26.78	0.47	0.09	0.06	4.65	11.6
Diaptomus ashlandi	2.15	3.20	7.71	3.40	3.37	2.44	3.71	9.2
Daphnia galeata *mendotae*	4.05	3.17	3.05	4.08	4.63	2.17	3.52	8.8
Ceriodaphnia quadrangula	0.47	0.09	18.48	0.41	1.06	0.20	3.45	8.6
Diaphanosoma leuchtenbergianum	0.37	0.41	15.75	0.38	0.50	0.58	3.00	7.5
Oligochaeta	0.12	0.00	0.09	0.12	0.23	0.00	0.09	02
Chydorus sphaericus	0.12	0.00	0.32	0.12	0.00	0.00	0.09	0.2
Eurycercus lamellatus	0.18	0.00	0.00	0.00	0.29	0.00	0.08	0.2
Diptera	0.00	0.06	0.23	0.00	0.18	0.00	0.08	0.2
Leptodora *kindtii*	0.14	0.12	0.06	0.00	0.12	0.00	0.07	0.2
Sida *crystallina*	0.06	0.00	0.00	0.00	0.29	0.06	0.07	0.2
Epischura nevadensis	0.00	0.00	0.06	0.00	0.00	0.31	0.06	0.2
Araneae (water spider)	0.00	0.12	0.00	0.00	0.23	0.00	0.06	0.1
Simocephalus vetulas	0.29	0.00	0.00	0.00	0.00	0.00	0.05	0.1
Cam ptocercus *rectirostris*	0.12	0.06	0.00	0.06	0.00	0.00	0.04	0.1
Hydra	0.06	0.06	0.00	0.06	0.06	0.00	0.04	0.1
Graptoleberis testudinaria	0.09	0.06	0.00	0.00	0.06	0.00	0.03	0.1
Rotifera	0.00	0.00	0.06	0.00	0.00	0.09	0.02	0.1
Ephemeroptera -	0.12	0.00	0.00	0.00	0.00	0.00	0.02	<0.1
Ostracoda (seed shrimp)	0.06	0.00	0.00	0.06	0.00	0.00	0.02	<0.1
Acarina (water mite)	0.06	0.00	0.00	0.00	0.00	0.00	0.01	<0.1
TOTAL	24.2	2~.W	120.6	29.95	29.of	15.1T	40.18	00.



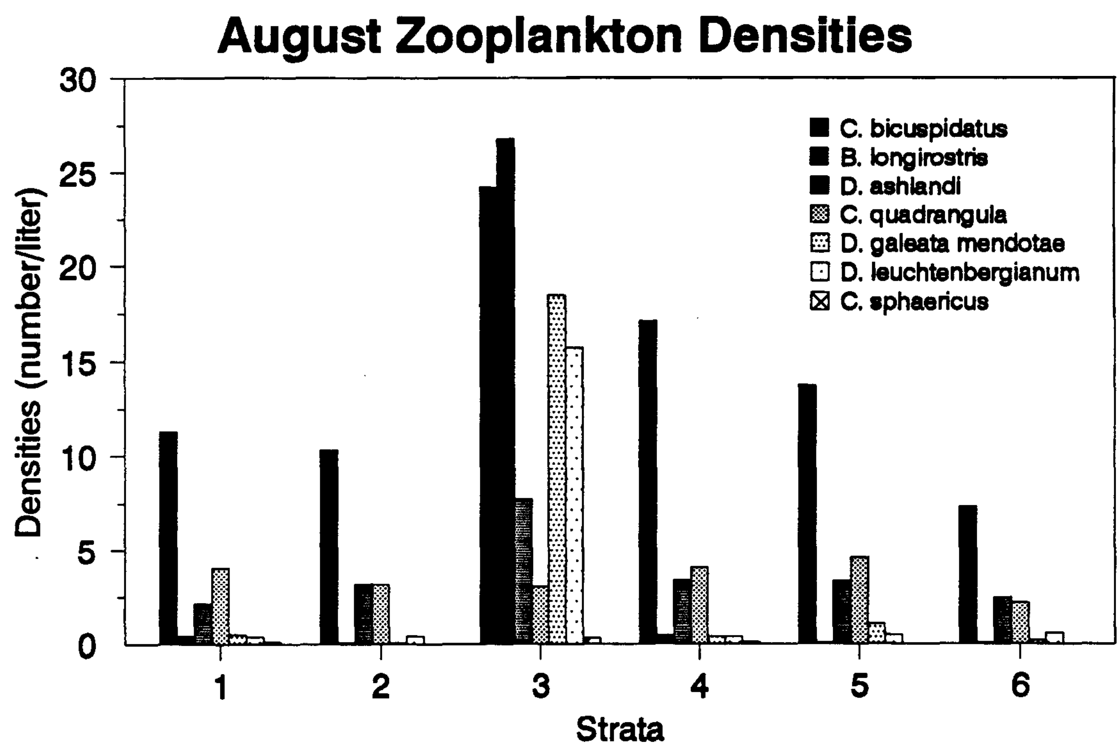
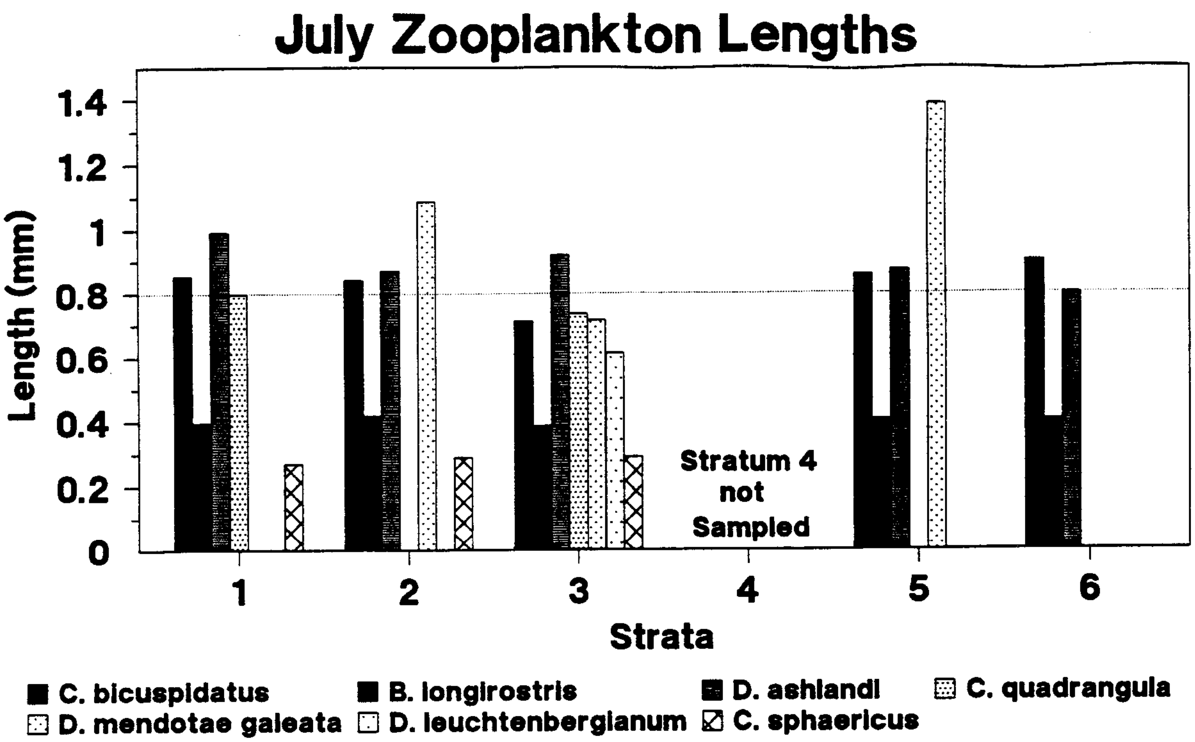


Figure 11. Density (number/liter) of the seven most abundant zooplankton species collected by strata during July 9-10 and August 5, 1991.



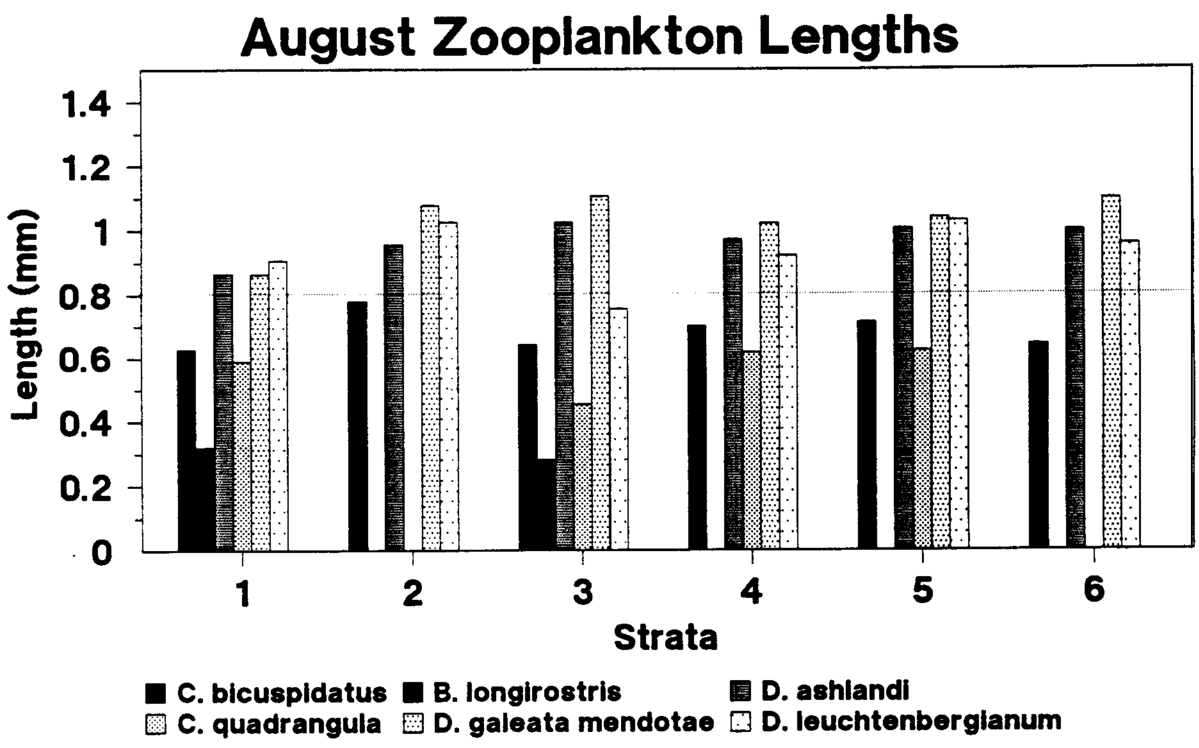


Figure 12. Mean length (mm) of the seven most abundant zooplankton species collected by strata during July 9-10 and August 5, 1991.

Table 4. Denisty (No/m2) of benthic invertebrates sampled at each strata of the Pend Oreille River during July 9-10 and August 18-20, 1991.
Stratum 4 was not sampled,

ORGANISM	STRATA 1 JULY n=15	1 AUGUST n=15	2 JULY n=10	2 AUGUST n=2	3 JULY n=10	3 AUGUST n=10	• 5 JULY n=10	5 AUGUST n=10	8 JULY n=10	8 AUGUST n=10	TOTAL	Relative Abundance
DIPTERA												
Chironomidae	494.8 (44.5)	151.1 (23.8)	297.8 (44.1)		315.6 (71.7)	346.7 (87.8)	102.2 (62.2)	111.1 (33.8)	355.8 (55.9)	88.9 (23.0)	2263.7	47.2
Tanyderidae	8.9 (0.8)		4.4 (0.7)		4.4 (1.0)						17.8	0.4
OLIGOCHAETA	177.8 (16.0)	269.6 (42.5)	57.8 (8.6)		80.0 (18.2)	35.6 (9.0)	40.0 (24.3)	204.4 (82.2)	44.4 (7.0)	71.1 (18.4)	980.7	20.5
AMPHIPODA											0.0	0.0
Gammaridae	130.4 (11.7)	14.8 (2.3)	93.3 (13.8)		4.4 (1.0)	8.9 (2.2)			88.9 (14.0)	88.7 (17.2)	407.4	8.5
PELECYPODA											0.0	0.0
Sphaeriidae	35.6 (3.2)	157.0 (24.8)	31.1 (4.0)		4.4 (1.0)		8.9	(5.44.4 (1.4)	35.8 (5.6)	22.2 (5.7)	299.3	8.2
TRICHOPTERA				•							0.0	0.0
Leptoceridae	38.5 (3.5)	11.9 (1.9)	26.7 (3.9)			4.4 (1.1)	4.4 (2.7)	4.4 (1.4)	31.1 (4.9)	84.4 (21.8)	205.9	4.3
Umnephilidae									4.4 (0.7)		4.4	0.1
GASTROPODA	83.0 (7.5)	20.7 (3.3)	75.8 (11.2)						13.3 (2.1)	8.9 (2.3)	201.5	4.2
EPHEMEROPTERA											0.0	0.0
Ceenidae	112.6 (10.1)	3.0 (0.5)	40.0 (5.9)		31.1 (7.1)		4.4 (2.7)				191.1	4.0
Ephemerides	20.7 (1.9)		17.8 (2.8)				4.4 (2.7)	4.4 (1.4)	31.1 (4.9)	31.1 (8.0)	109.8	2.3
RHYNCHOBDELLIDA											0.0	0.0
Glossiphoniidae	3.0 (0.3)	3.0 (0.5)	4.4 (0.7)						31.1 (4.9)	13.3 (3.4)	54.8	1.1
HEMIPTERA											0.0	0.0
Cicadellidae				22.2 (100)							22.2	0.5
CLADOCERA											0.0	0.0
Sididae	3.0 (0.3)		17.8 (2.8)								20.7	0.4
ODONATA											0.0	0.0
Coenagrlldae	3.0 (0.3)		8.9 (1.3)								11.9	0.2
MEGALOPTERA											0.0	0.0
Sialidae		3.0 (0.5)									3.0	0.1
IOtAL	1111.1	634.1	675.6	223	440.0	395.6	184.4	328.9	8358	386.7	4794.1	100.0

* Sampling was not efficient due to rock and gravel substrate.

Table 5. Biomass (g/m2) of benthic invertebrates sampled at each strata of the Pend Oreille River during July 9-10 and August 18-20, 1991. Stratum 4 was not sampled.

						STRATA						
		1		2 •	-	3	•	5		6		Relative Abundance
ORGANISM	JULY n=15	AUGUST n=15	JULY n=10	AUGUST n=2	JULY n=10	AUGUST n=10	JULY n=10	AUGUST n=10	JULY n=10	AUGUST n=10	TOTAL	
DIP TERA												
Chironomidae	p.9858 (41.9)	0.1890 (8.3)	1.8902 (53.8)		2.4707 (85.9)	0.9653 (91.4)	0.3547 (38.9)	0.9720 (33.3)	0.4358 (4.6)	0.2582 (10.4)	10.5215	31.5
Tanyderidae	0.0116 (0.2)		0.0004 (<0.1)		0.0053 (0.2)						0.0173	0.1
EPHEMEROPTERA												
Caenidae	0.3037 (4.3)	0.0216 (0.7)	0.0929 (2.8)		0.0729 (2.5)		0.0076 (0.8)				0.4987	1.5
Ephemeridae	2.2030 (30.9)		0.4840 (13.2)				0.0711 (7.8)	0.2418 (8.3)	3.1413 (33.0)	0.9200 (37.1)	7.0412	21.1
PELECYPODA												
Sphaeriidae	0.1603 (2.3)	0.3987 (13.2)	0.0478 (1.4)		0.0027 (0.1)		0.1813 (19.9)	1.2307 (42.2)	4.7120 (49.5)	0.0587 (2.4)	6.7899	20.3
OLIGOCHAETA	0.5078 (7.1)	1.0281 (34.2)	0.1751 (5.0)		0.3124 (10.9)	0.0507 (4.8)	0.2244 (24.6)	0.4627 (15.9)	0.4524 (4.8)	0.8342 (25.8)	3.8477	11.5
									0.0458 (0.5)	0.0524 (2.1)	1.8455	5.5
GASTROPODA	0.3449 (4.8)	1.1081 (36.9)	0.2942 (8.4)									
TRICHOPTERA												
Leptoceridae	0.2424 (3.4)	0.1079 (3.6)	0.2213 (8.3)			0.0004 (<0.1)	0.0738 (8.1)	0.0107 (0.4)	0.0969 (1.0)	0.4489 (18.1)	1.2022	3.8
Umnephilidee									0.0040 (<0.1)		0.0040	<0.1
AMPHIPODA												
Gammaridee	0.1852 (2.6)	0.0323 (1.1)	0.1413 (4.0)		0.0107 (0.4)	0.0400 (3.8)			0.2724 (2.9)	0.0818 (3.3)	0.7637	2.3
RHYNCHOBDELLIDA												
Gloesiphoniidee	0.0881 (1.0)	0.0858 (2.8)	0.0187 (0.5)						0.3580 (3.7)	0.0240 (1.0)	0.5524	1.7
ODONATA												
Coenagriidae	0.1102 (1.5)		0.1558 (4.4)								0.2058	0.8
MEGALOPTERA												
Sialidee		0.0378 (1.3)									0.0370	0.1
HEMIPTERA												
Cicadellidae				0.0311 (100)							0.0311	0.1
CLADOCERA												
Sididae	0.0003 (<0.1)		0.0089 (0.3)								0.0092	<0.1
IOTAL	7.1230	3.0011	3.5102	_ 0.0311	2.8747	1.0584	0.9129	2.9178	9.5184	2.4762	33.42/8	100.0

* Sampling was not efficient due to a rock and gravel substrate.

biomass in stratum 3 (sloughs) was consistently lower than all other habitat types. Ephemeridae (second highest overall biomass) was never sampled in stratum 3. We found no trends in macroinvertebrate biomass between littoral (strata 1 and 2) and pelagic (strata 5 and 6) habitats.

Aquatic Macrophytes

Fourteen submerged aquatic macrophyte species were sampled in Pend Oreille River, Idaho during 1992 representing seven families (Table 6). The most abundant species collected was *Potamogeton berchtoldii* followed by *Myriophyllum spicatum exalbescens*. Both species represented 63% of the total biomass of macrophytes.

Submerged aquatic macrophytes occupied 14% of the total surface area of the Pend Oreille River (Figure 13). Distribution of aquatic macrophytes generally coincided with small substrate size (< 1 mm) and water depth from 3 to 6 m with variation between 1991 and 1992. Aquatic macrophytes generally inhabited shallower waters in 1992 than in 1991. Sloughs with water < 3.5 m deep generally were vegetated, although at lower densities than sloughs with water >3.5m deep. Sloughs > 3.5 m deep had the highest average aquatic macrophyte biomass (oven-dry weight) with an average weight of 131.3 g/m^2, whereas sloughs < 3.5 m deep had an average biomass of 58.7 g/m^2 (Table 6). Macrophytes in stratum 5 had an average biomass of 81.7 g/m^2 in the littoral zone > 3 m, while midriver samples had an average biomass of 1.5 g/m^2. Samples collected from stratum 6 in the littoral zone with depths > 3 m had an average biomass of 51.6 g/m^2.

DISCUSSION

Physico-Chemical Conditions

Temperature and Dissolved Oxygen

Water temperatures of the Pend Oreille River are not ideal for centrarchids or salmonid fishes. Centrarchids prefer temperatures > 21°C, while salmonids do not inhabit waters with temperatures much > 21°C (Everhart and Youngs 1981; Scott and Crossman 1973; Carlander 1969). Daily average temperatures were > 21°C for more than a month but never > 22.5°C. Temperatures > 21°C make survival for salmonids difficult (Carlander 1969; Stevenson 1987). Without a thermocline for sanctuary, as occurred during 1991, the Pend Oreille River provides little suitable habitat for salmonids. Although the river did stratify during 1992, it is possible that unusually low flows contributed to the stratification. Scott and Crossman (1973) indicated that the preferred temperatures for brown trout range from 12.8 to 24°C depending on the stock. Brown trout in the Pend Oreille River may have adapted to warmer water temperatures as fish sampled during the warmest months (22.5°C) were stocky and looked healthy. Brown trout were sampled throughout all strata.

Table 6. Average biomass (g/m2) of aquatic macrophytes collected from sloughs and along the main river channel during August 1, 1992.

FAMILY Species	Sloughs <3.5 m	Sloughs >3.5 m	Stratum	Main River	Stratum 6	Overall Average	Relative Abundance
CERATOPHLLACEAE							
Ceratophyllum demersum			30.50348			3.3893	9.4
CHARACEAE (Alga)							
Chara spp.	0.0714		6.718925			0.7545	2.1
HYDROCHARITACEAE							
Elodea canadensis		0.0649	0.648475			0.0793	0.2
Elodea nuttallii	1.78445	5.0508	7.90683	0.0291	2.1874	1.8843	5.2
HALORAGACEAE							
Myriophyllum spicatum exalbescens	0.8827	36.0154	21.8908	1.3846	1.8605	6.8927	19.1
NAJADACEAE							
Najas *flexilis*	5.3547				2.9657	0.9245	2.6
POTAMOGETONACEA							
Potamogeton berchtoldii	31.4467	86.3386	0.630675		24.9786	15.9327	44.1
Potamogeton *crispus*			4.603225		19.1314	2.6372	7.3
Potamogeton foliosus	0.06415	0.605	0.1007			0.0855	0.2
Potamogeton pectinatus		2.0368	0.00645		0.493	0.2818	0.8
Potamogeton richardsoni	17.2001	1.1816	2.880125			2.3624	6.5
Potamogeton robbinsii			5.372025			0.5969	1.7
Potamogeton zosteriformis			0.0127			0.0014	0.0
RANUNCULACEAE							
Rununculus longirostris	1.91315		0.429525	0.08338		0.2696	0.7
I U IAL	58.71735	131.2931	81.70393	1.49708	51.6166	36.0920	100.0

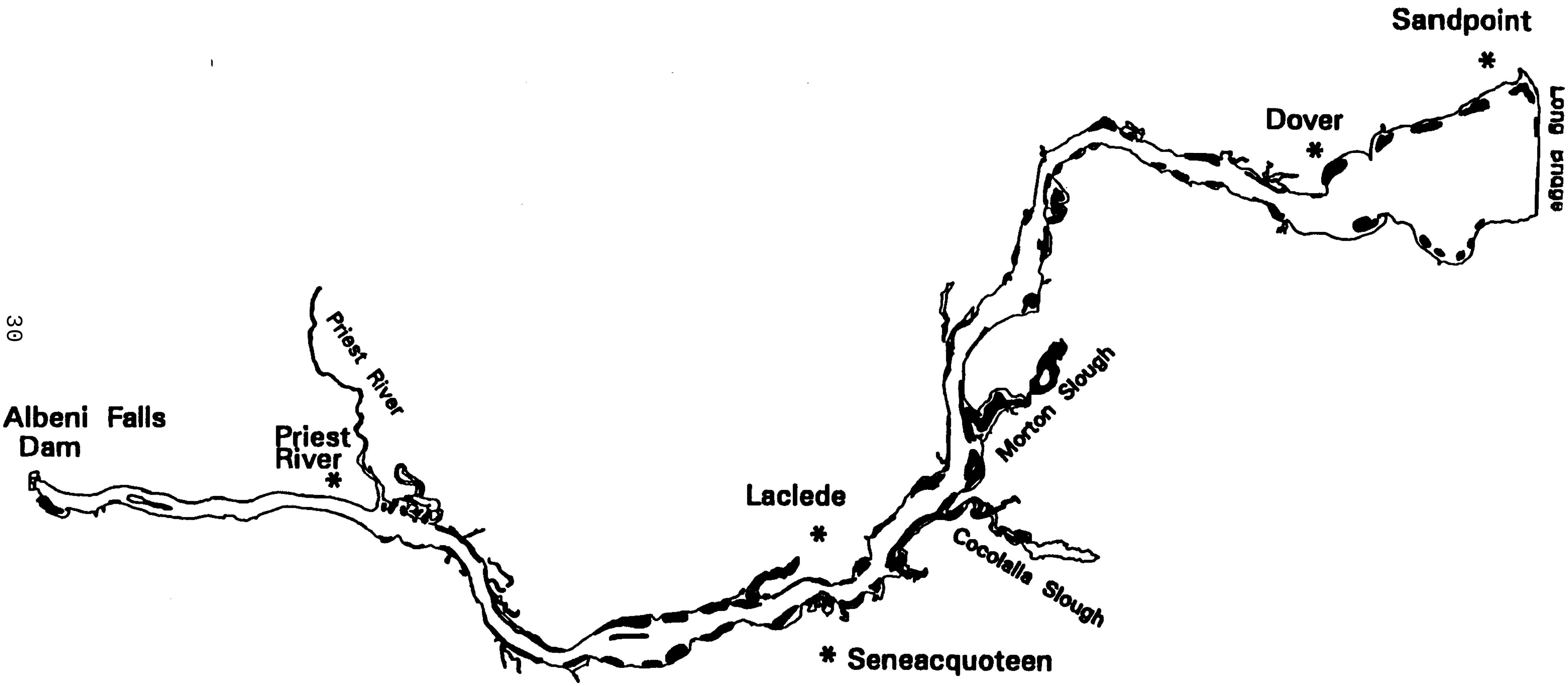


Figure 13. Distribution of submerged aquatic macrophytes on Pend Oreille River, Idaho depicted by black shading.

Although temperatures were > 21°C, they were well below the optimum (27°C) for largemouth bass and black crappie (Coutant and DeAngelis 1983; Carlander 1977). The Pend Oreille River experienced a growing season of 1,146 (1991) to 1,334 (1992) degree days > 10°C. Growing seasons > 1,100 degree days are typical for bass fisheries in the Northwest. Liter (1991) reported a growing season of 1,160 degree days in Box Canyon Reservoir, Washington immediately downstream of Albeni Falls Dam. Bowles (1985) reported growing seasons of 905 and 1,300 degree days (> 10°C) in Blue Lake, Idaho which is known as a good bass fishery.

Dissolved oxygen samples were always > 6 mg/L which is considered to be sufficient for most sport fish (Everhart and Youngs 1981). High dissolved oxygen levels in Pend Oreille River may have contributed to the presence of brown trout at higher temperatures.

Conductivity, Transparency, pH and Phosphorous

Conductivity varied inversely with discharge. During spring when flows were highest conductivity was lowest, whereas during November when flows were lowest conductivity was highest. Conductivities ranging from 120 to 160 umhos typify large river systems, such as the Pend Oreille River, and carry large quantities of dissolved solids (C.M. Falter, University of Idaho, personal communication).

Transparency (secchi readings), pH and total phosphorus readings indicate the Pend Oreille River is meso-oligotrophic. Goldman and Horne (1983) and Wetzel (1983) indicated a pH near 7.0 typifies oligotrophic water, whereas a higher daytime pH typifies a more productive system. During June and October, daytime pH levels were generally around 8.5 with the pH dropping to around 7.25 in March.

Secchi disk readings from 2-7 m tend to indicate mesotrophic waters whereas readings < 2 m tend to indicate eutrophic waters (Goldman and Horne 1983; Wetzel 1983). Secchi readings in the main river ranged from 1.2 to 4.4 m with most readings > 2 m. Secchi readings in the sloughs ranged from 0.8 to 2.9 m with most readings < 2 m. Total phosphorus (PO_4) levels from 9-24 ug/L typify mesotrophic waters, whereas eutrophic waters typically have total phosphorus readings > 24 ug/L (Goldman and Horne 1983; Wetzel 1983). Total phosphorus levels in Pend Oreille River ranged from 15.9 to 4.6 ug/L in the sloughs and 8.3 to 2.4 ug/L in the main river.

Water Level Fluctuations

Water increments of 69 cm/d can cause nest abandonment of largemouth bass, whereas increments of 6 cm/d have resulted in strong year classes (Mitchell 1982). During 1991 largemouth spawning occurred after the reservoir was filled, whereas in 1992 the reservoir continued to rise for 13 days after ideal spawning temperatures were reached. Water levels rose an average of 8 cm/d, thus levels were probably not impacting spawning success for centrarchids. Also, age-0 largemouth bass were abundant during 1991 and 1992.

Spawning of brown trout was observed during late October and early November in Hoodoo Creek. If spawning were occurring in the main river at this time, as is suspected, water levels would have been decreasing. From November 1 to the beginning of lowpool, water levels dropped 0.9 m in 1991 and 0.95 m in 1992. Suitable spawning habitat for brown trout in Pend Oreille River is located in waters > 1 m deep, thus this type of level fluctuation would not be expected to dewater redds.

Few kokanee were sampled in the Pend Oreille River and we observed no signs of spawning. However, decreasing water levels during this time could have serious affects on spawning kokanee in Pend Oreille Lake.

Substrate Composition

Local residents indicate the Pend Oreille River once had gravel bars suitable for salmonid spawning. Currently the river is dominated by fine substrates. Large clouds of sediment were often observed from wave action against clay banks. Wave action on exposed banks have created excessive siltation filling in gravel bars once suitable for spawning salmonids. Low velocities do not allow for gravel cleaning.

Brown trout prefer substrate sizes of 20-50 mm (Shirvell and Dungey 1983; Crisp and Carling 1989). These substrate sizes are limited and the largest concentration is located at the mouth of Priest River. Lack of suitable spawning habitat could be limiting brown trout numbers.

River Velocities and Depth

Water velocity is an important habitat characteristic for fishes. Salmonids prefer velocities ranging from 20 to 50 cm/s for spawning, whereas centrarchids require zero velocities for overwintering (Crisp and Carling 1989; Grost et al. 1990; Sheehan et al. 1990; Pitlo 1992). The majority of the Pend Oreille River is dominated by low velocities (0-18 cm/s); velocities ranging from 20 to 50 cm/s occur in the narrow portions of the river, especially below Priest River.

During winter, drawdown dewaters many backwater areas that would typically provide areas of zero velocities. Centrarchids may be forced from these preferred areas into areas with unsuitable velocities and less suitable overwintering habitat.

The depth of Pend Oreille River is variable and provides opportunities for many fishes. Shallow sloughs provide habitat for centrarchids and deep pools provide sanctuary for larger salmonids. These variations in depth within Pend Oreille River provide diverse habitats for the introductions of new species.

Biological Components

Zooplankton

The zooplankton population in Pend Oreille River is abundant and diverse with densities ranging from 15 to 120 organisms/L representing over 25 species. Largemouth bass < 75 mm, yellow perch < 200 mm, black crappie < 200 mm and pumpkinseed Lepomis gibbosus feed predominantly on zooplankton (Timmons et al. 1981; Mills and Schiavone 1982; Ashe 1991). Dietary overlap of these fishes on zooplankton may occur and could result in interspecific interactions. Numerous juvenile northern squawfish, peamouth Mylocheilus caurinus and redside shiner Richardsonius balteatus were sampled in the Pend Oreille River which may increase interspecific competition for zooplankton.

Mean length of zooplankton is an indicator of a system's predator-prey balance (Mills and Schiavone 1982; Mills et al. 1987). If zooplankton sizes are < 0.8 mm during August an overabundant planktivore community may exist. The most abundant zooplankton species collected (37%) in Pend Oreille River is C. bicuspidatus and therefore, optimal foraging theory (Brooks and Dodson 1965) suggests it is probably the most preferred forage for planktivores. Sampling during July 1991 revealed average sizes > 0.8 mm (near 0.9 mm) in all strata except stratum 3 (0.7 mm) where the highest number of fishes were caught. Stratum 3 had the highest densities of zooplankton which could also account for the reduced size of zooplankton, as competition for phytoplankton may occur. During August 1991 when age-0 fishes are most numerous, the average size of C. bicuspidatus decreased to < 0.8 mm in all strata suggesting that overcropping of C. bicuspidatus may be occurring. During August, densities of D. ashlandi, D. galeata mendotae, and D. leuchtenbergianum increased. Each of these species had average sizes > 0.8 mm during August and their combined relative abundance accounted for about 30% of the community. The increase in abundance of these species caused the overall average size of the seven most abundant zooplankton species to increase from 0.7 mm in July to 0.8 mm August. Average zooplankton sizes during August suggest that cropping of zooplankton is not occurring as fishes may be switching to other forage items.

Post and McQueen (1987) found that high fish densities were associated with small cladoceran, primarily Bosmina, and in areas where the zooplankton community was dominated by large cladocerans, primarily daphnids, fish densities were low. High densities of B. longirostris were collected in Pend Oreille River, Idaho during July and August in stratum 3 (sloughs), whereas densities of larger zooplankton species were dominant in the other strata.

Benthic Invertebrates

Densities of benthic invertebrate samples from Pend Oreille River, Idaho were similar between all strata, except stratum 3 (sloughs) which consistently showed the lowest densities and diversities. During the winter, sloughs are dewatered reducing the maximum depths to < 1.2 m (4 ft). Dewatered areas are exposed to desiccation and freezing and shallow waters may freeze solid. A combination of drawdown and harsh winter conditions are probably responsible for low densities and low biomass of benthic invertebrates in the sloughs. Low densities of benthos may adversely affect the growth of fishes in the sloughs.

Dipterans and oligochaetes were the most abundant species sampled in all strata and represented > 50% of the numbers and 40% of the biomass. The Ephemeridae, Hexegenia limbata, is the largest of all mayflies and has a larval stage to 2 years. This burrowing mayfly often represented over 30% (2% by number) of the biomass of the benthic invertebrates sampled. Although Hexegenia limbata is an important food item for all fish species sampled (Objective 3), they were not sampled in the sloughs which may indicate the harsh winter conditions may affect its survival.

Aquatic Macrophytes

Submerged aquatic macrophytes occupy 14% of the total surface area of the Pend Oreille River. Their importance is to provide structure for fishes. Durocher et al. (1984) found that as percent submerged aquatic macrophyte densities increased, standing crop of largemouth bass and recruitment to harvestable size increased. Local residents claim aquatic macrophyte distribution is expanding which may lead to increased numbers of largemouth bass.

Submerged aquatic macrophytes are generally found in areas of low velocity and small substrate size. The annual drawdown controls the distribution of aquatic macrophytes as growth is typically limited to depths > 3.0 m. Plants growing in waters < 3.5 m deep are subjected to freezing and desiccation during the winter. Sloughs < 3 m deep often contain vegetation. We believe that springs and tributaries keep sloughs wet during the winter and prevent macrophyte roots from dying. Aquatic macrophytes were found in shallower waters during 1992 than 1991 indicating the mild winter during 1992 was probably not cold enough to kill many of the aquatic macrophytes.

Box Canyon Reservoir, immediately downstream from Albeni Falls Dam, had peak macrophyte densities ranging from 388 to 578 g/m^2 the highest densities sampled in waters < 3 m deep (Falter et al. 1991). These biomasses are around five times higher than above Albeni Falls Dam. The major difference between Box Canyon Reservoir and Pend Oreille River, Idaho is absence of annual drawdown.

Box Canyon Reservoir has dense stands of the exotic macrophyte Myriophyllum spicatum spicatum which often comprises > 50% of the macrophyte community (Falter et al. 1991). Myriophyllum spicatum spicatum was generally not sampled in depths > 3 m (Falter et al. 1991). Drawdown of the Pend Oreille River typically restricts aquatic macrophyte growth to depths > 3 m which may explain why M. spicatum spicatum has not been established above Albeni Falls Dam.

Objective 2. To assess the relative abundance of fishes and determine fish habitat associations as related to drawdown in Pend Oreille River, Idaho.

METHODS

Relative abundance and distribution of fishes were determined by random collections in each of the six strata (Figure 1; Appendix Table 1). Two or three sampling stations were randomly selected from each stratum. A variety of techniques were used to sample littoral strata to alleviate sampling bias, these include gill netting, electrofishing and beach seining. Gill netting was also used to sample pelagic strata (strata 4, 5 and 6). Sampling occurred during each river stage (Table 7) unless high flows precluded sampling.

Gill nets were set in the evening and checked the following morning. Two nights of effort were completed at each station. Sets were perpendicular to shore with the smallest mesh size alternated towards and away from shore. Two groups of six nets were used for sampling. Each group was composed of one floating and five sinking experimental gill nets. Two sinking nets were multifilament with five, 14.6 x 1.8 m (48 x 6 ft) panels with mesh size (stretch) ranging from 38.1 (1.5 in) to 139.7 mm (5.5 in). Two other sinking nets were monofilament with five, 9.1 x 1.8 m (30 x 6 ft), panels with mesh size ranging from 38.1 to 139.7 mm. One sinking net was multifilament with seven, 7.6 x 1.8 m (25 x 6 ft), panels with mesh size ranging from 51 (2 in) to 203 mm (8 in). The floating experimental gill nets were multifilament with five, 14.6 x 1.8 m (48 x 6 ft) panels with mesh size (stretch) ranging from 138.1 to 139.7 mm. The floating gill nets were submerged to the bottom in areas of heavy boat traffic. Variation in gill net size and type, and placement of small mesh size towards and away from shore limited sampling bias. One sampling unit was composed of six gill nets.

Nighttime electrofishing consisted of 10 minutes of shocking effort at each littoral sampling station. Electrofishing was conducted by paralleling the shoreline in waters generally < 1.3 m deep with a constant output of approximately 400 volts and 3.5 amps. Electrofishing was repeated at each station for three nights during refill and highpool and for two nights during drawdown and lowpool to minimize night to night variation.

Three standardized beach seine hauls were conducted at each littoral sampling station with each haul covering an area (454 m^2) undisturbed by a previous haul. Beach seining was repeated twice at each littoral sampling station to minimize variation. Beach seining was conducted during refill and highpool during 1991 and refill during 1992.

All fish sampled were identified, counted and measured for total length (mm). Attempts were made to collect weights (g) and scale samples for each 10 mm length increment for largemouth bass, black crappie, yellow perch and trout.

Table 7. Sampling dates and drawdown stages in the Pend Oreille River, Idaho.

Stage	Date of Stage	Sampling Date
Refill	Mid-April to Mid-June	Mid-May to Mid-June
Early Highpool	Mid-June to Late July	Late June to Late July
Late Highpool	Late July to Late Aug.	Late July to Late Aug.
Drawdown	Mid-Sept. to Mid-Nov.	Mid to Late October
Lowpool	Mid-Nov. to Mid-April	Mid-May

Relative abundance of fishes were determined at each stratum during each stage of drawdown. Length frequency graphs were constructed for largemouth bass, black crappie, yellow perch, cutthroat trout, rainbow trout and brown trout.

Fish habitat use during each stage of drawdown was determined through chi-square tests of homogeneity. Calculations determined if fishes were uniformly distributed throughout the system or utilized specific strata. Tests were performed on the more abundant species (yellow perch, peamouth and northern squawfish) and selected game species (largemouth bass, black crappie, rainbow trout, cutthroat trout and brown trout). Gill netting was used, as this technique sampled each stratum whereas electrofishing and beach seining sampled only littoral strata. Because largemouth bass, black crappie, rainbow trout, cutthroat trout and brown trout were sampled in low numbers, their catches were combined into two periods, cool temperatures (drawdown, lowpool and refill) and warm temperatures (early and late highpool). By combining catches into two periods we were able to compare chi-square tests for selected game species.

RESULTS

Species Composition and Relative Abundance

A total of 15,743 net hours of gill netting, 1,422 minutes of nighttime electrofishing, and 147 beach seine hauls were used to determine the fish community in the Pend Oreille River, Idaho. Sampling during 1991 and 1992 included all stages of drawdown (refill, early highpool, late highpool, drawdown and lowpool) and resulted in a collection of 45,475 fishes representing 24 species (Table 8). Most fish (19% in 1991; 31% in 1992) were sampled from stratum 3 (sloughs) and the fewest (1% in 1991; 1% in 1992) from stratum 4 (pelagic, below Priest River). Yellow perch, peamouth and northern squawfish, the three more abundant species during 1991 and 1992, represented 64.1% and 59.4% of the catch. All salmonid species common to northern Idaho (lake whitefish *Coregonus clupeaformis,* mountain whitefish, cutthroat trout, rainbow trout, kokanee, bull trout, brook trout *S. fontinalis,* lake trout *S. namaycush* and brown trout) were sampled in the study area. A total of 499 trout (1.9%) were sampled in 1991 and 199 (0.6%) during 1992. Of these salmonids, rainbow trout were most commonly caught during 1991 (0.6%), whereas during 1992 brown trout were most common (0.2%). Largemouth bass catches increased from 316 (1.2%) during 1991 to 654 (3.3%) during 1992. During 1991, 313 (1.2%) black crappies were sampled whereas 234 (1.2%) were sampled in 1992.

Lowpool was sampled during 1992. The most abundant fishes sampled were peamouth, redside shiner, northern squawfish and yellow perch in decreasing order of abundance and represented 71.5% of the total catch (Table 9). During 1992, relative abundance of trout (1.5%) was highest at lowpool, whereas largemouth bass relative abundance was lowest (0.2%). Twenty-eight black crappie were sampled representing 1.3% of the catch.

Table 8. Number of fishes sampled by all gear types within each stratum from the Pend Oreille River, Idaho during 1991 and 1992.

						STRATA									PERCENT COMPOSITION		RANK	
		1		2		3		4		5		6	TOTAL					
Species	1992	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
kokanee salmon	36	1	8		58					1	10	1	112	3	0.44	0.02	16	19
cutthroat trout	78	10	30	16	15	7					14	4	137	37	0.53	0.19	15	14
cutthroat (hatchery)	30	3		2	2	1							32	6	0.12	0.03	18	17
rainbow trout	121	13	23	8	15		1				3	2	163	23	0.63	0.12	13	15
rainbow (hatchery)	2				1								3	0	0.01	0.00	21	22
brown trout	17	12	6	17	10	8			3	4	3		39	41	0.15	0.21	17	13
brook trout	1		1		2	1							4	1	0.02	0.01	20	21
bull trout	2	1		1							1		3	2	0.01	0.01	21	20
lake trout	1	2	3							4	2		6	8	0.02	0.03	19	17
lake whitefish	6	35	8	33	15	3		2	29	103	88	170	146	348	0.57	1.75	14	12
mountain whitefish	846	401	180	62	243	22	5	2	28	28	218	132	1520	647	5.92	3.27	5	10
peamouth	1080	695	887	529	1045	601	24	54	373	352	1384	1643	4793	3874	18.66	19.58	2	2
northern squawfish	1393	789	1470	1456	889	383	156	117	241	317	297	208	4446	3270	17.31	16.53	3	3
redside shiner	418	272	1024	874	429	15		14		2	3	1	1874	1178	7.30	5.95	4	6
tench	397	305	141	257	551	599	3		28	6	54	63	1174	1230	4.57	6.22	7	5
longnose sucker	264	104	183	79	161	157	1	4	36	15	125	122	770	481	3.00	2.43	9	11
largescale sucker	457	269	361	302	325	124	26	34	64	87	72	72	1305	888	5.08	4.49	6	8
brown bullhead	222	160	46	71	715	720		1	14	4	23	35	1020	991	3.97	5.01	8	7
channel catfish	1												1	0	0.00	0.00	23	22
pumpkinseed	42	159	17	141	225	955			3		1		288	1255	1.12	6.34	12	4
smallmouth bass	1												1	0	0.00	0.00	23	22
largemouth bass	68	81	19	101	229	472							316	654	1.23	3.31	10	9
black crappie	46	47	33	20	231	167			3				313	234	1.22	1.18	11	13
yellow perch	2409	1330	896	866	3261	1872	26	25	437	186	192	325	7221	4604	28.11	23.27	1	1
slimy sculpin		2	1	14									1	16	0.00	0.08	23	16
TOTAL	7938	4691	5337	4849	8422	6107	242	253	1259	1109	2490	2778	25688	19787	100	100		

Table 9. Number of fishes sampled by all gear types within each stratum from the Pend Oreille River, Idaho during lowpool (March 1992). No sampling occurred in stratum 4.

	Stratum							%	
Species	1	2	3	4	5	6	Total	Comp	Rank
kokanee salmon	1						1	0.05	20
cutthroat trout	4	6	6			1	17	0.81	12
cutthroat (hatchery)	3						3	0.14	18
rainbow trout	3	1					4	0.19	16
rainbow (hatchery)							0	0.00	22
brown trout					2		2	0.09	19
brook trout							0	0.00	22
bull trout		1					1	0.05	20
lake trout	1				3		4	0.19	16
lake whitefish	26	7	3			34	70	3.32	9
mountain whitefish	8	2	11			1	22	1.04	11
peamouth	186	84	243		40	144	697	33.03	1
northern squawfish	42	117	25		41	27	252	11.94	3
redside shiner	3	315	1				319	15.12	2
tench	45	5	35			3	88	4.17	7
longnose sucker	10	29	22		1	21	83	3.93	8
largescale sucker	56	35	27		12	14	144	6.82	5
brown bullhead	19	2	82			1	104	4.93	6
channel catfish							0	0.00	22
pumpkinseed	5	2	7				14	0.66	13
smallmouth bass							0	0.00	22
largemouth bass	2		3				5	0.24	15
black crappie	10		18				28	1.33	10
yellow perch	116	12	103		7	3	241	11.42	4
slimy sculpin	2	9					11	0.52	14
TOTAL	542	627	586	0	106	249	2110	100	

Peamouth, northern squawfish and yellow perch were the more common fishes sampled during refill representing 60.7 and 60.8% of the catch in 1991 and 1992 (Table 10). Trout catches were the highest during refill for 1991 and second highest during 1992. Sampling during refill accounted for 220 (3.5%) fishes during 1991 and 41 (0.8%) during 1992. The lowest relative abundance for largemouth bass occurred during refill for 1991 (0.3%) and the second lowest for 1992 (0.7%). Black crappie represented 1.3 and 0.7% of the catch during 1991 and 1992. Strata 4 and 5 could not be sampled as a result of high flows.

During early highpool yellow perch, northern squawfish and peamouth were the predominant species representing 71.1 (1991) and 56.2% (1992) of the catch (Table 11). Relative abundance of trout decreased from refill to early highpool and represented 1.8 (1991) and 0.4% (1992) of the catch. Relative abundance of largemouth bass increased during early highpool representing 0.2 and 3.7% of the catch during 1991 and 1992. Black crappie represented 0.8 (1991) and 1.5% (1992) of the catch during early highpool.

During late highpool yellow perch, peamouth and northern squawfish dominated the catch representing 57.9 (1991) and 56.8% (1992) of the catch (Table 12). Trout relative abundance decreased during late highpool as they represented 1.3% of the catch during 1991 and 0.2% for their lowest relative abundance during 1992. Largemouth bass relative abundance was highest during late highpool representing 2.9 (1991) and 9.3% (1992) of the catch. Black crappie represented 0.9 (1991) and 1.4% (1992) of the catch during late highpool.

During drawdown yellow perch, peamouth and northern squawfish were the more abundant species sampled as they represented 70.7 (1991) and 70.4% (1992) of the catch (Table 13). Relative abundance of trout decreased to the lowest abundance during drawdown (0.9%) in 1991 and further decreased (0.6%) during 1992. Relative abundance of largemouth bass decreased to 0.8% of the catch during 1991 and 1.1% during 1992. Relative abundance for black crappie ranged from 3.4 to 1.0% during 1991 and 1992.

Habitat Selection

Chi-square homogeneity tests during lowpool indicate yellow perch and peamouth are not distributed uniformly throughout each stratum ($P < 0.001$), whereas northern squawfish were uniformly distributed ($P > 0.10$). During lowpool yellow perch selected stratum 1, as the catch was over three times higher than expected (Table 14). Strata 2, 5 and 6 were avoided by yellow perch. Stratum 4 was not sampled during lowpool due to high water velocities. Peamouth preferred stratum 6 (observed >2 times than expected) and tended to avoid strata 2 and 5.

Chi-square homogeneity tests during refill show significant differences in habitat selection for yellow perch, peamouth and northern squawfish ($P < 0.001$) (Table 14). During refill, yellow perch selected stratum 3 (observed > 2.1 expected) and avoided strata 2, 4 and 6. Peamouth showed the strongest selection for stratum 6 (observed > 1.6 expected) and avoided strata 4 and 5. Northern

Table 10. Number of fishes sampled by all gear types within each stratum from the Pend Oreille River, Idaho during refill (mid-May to mid-June) 1991 and 1992. Strata 4 and 5 were not sampled during 1991.

						STRATA							TOTAL		PERCENT COMPOSITION		RANK	
		1		2		3		4		5		6						
Species	1992	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
kokanee salmon	30		2		57					1	1		90	1	1.44	0.02	10	19
cutthroat trout	38	1	5	2	8	1						2	51	6	0.82	0.11	12	16
cutthroat (hatchery)	24				1								25	0	0.40	0.00	14	22
rainbow trout	28	5	1	3	2						1	2	32	10	0.51	0.19	13	15
rainbow (hatchery)	1												1	0	0.02	0.00	21	22
brown trout	4	6	3	7	4	8					2		13	21	0.21	0.39	16	14
brook trout					2	1							2	1	0.03	0.02	19	19
bull trout	2	1											2	1	0.03	0.02	19	19
lake trout		1	3							1	1		4	2	0.06	0.04	18	17
lake whitefish	139	7	60		215					56	76	115	490	178	7.86	3.31	5	8
mountain whitefish	*	86	*	15	*	2				5	*	55	*	163	*	3.03	*	10
peamouth	401	181	273	142	696	250		10		48	370	495	1740	1126	27.90	20.93	1	1
northern squawfish	398	210	364	464	408	166		45		54	67	67	1237	1006	19.83	18.70	2	3
redside shiner	263	40	155	326	391	6		14				1	809	387	12.97	7.19	4	4
tench	50	112	4	108	136	95				1	4	14	194	330	3.11	6.13	8	6
longnose sucker	73	26	1	22	53	70		1		8	10	31	137	158	2.20	2.94	9	11
largescale sucker	114	45	63	90	98	74		17		28	7	18	282	272	4.52	5.06	6	7
brown bullhead	49	50	2	14	147	305					8	11	206	380	3.30	7.06	7	5
channel catfish													0	0	0.00	0.00	23	22
pumpkinseed	1	23		45	12	105							13	173	0.21	3.22	16	9
smallmouth bass													0	0	0.00	0.00	23	22
largemouth bass	2	5	1	10	14	25							17	40	0.27	0.74	15	12
black crappie	1	10	1		77	28							79	38	1.27	0.71	11	13
yellow perch	92	220	48	357	644	316		13		98	28	81	812	1085	13.02	20.17	3	2
slimy sculpin			1	2									1	2	0.02	0.04	21	17
TOTAL	1710	1029	987	1607	2965	1452	0	100	0	300	575	892	6237	5380	100	100		

* Mountain whitefish and lake whitefish were grouped together in 1991 due to misidentification.

Table 11. Number of fishes sampled by all gear types within each stratum from the Pend Oreille River, Idaho during early highpool (July) 1991 and 1992.

	STRATA														PERCENT COMPOSITION		RANK	
	1		2		3		4		5		6		TOTAL					
Species	1992	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
kokanee salmon	3		3		1							1	7	1	0.09	0.02	17	17
cutthroat trout	31	1	8	3	7						2	1	48	5	0.61	0.09	13	15
cutthroat (hatchery)	6				1								7	0	0.09	0.00	17	18
rainbow trout	. 51	3	12		4		1						68	3	0.87	0.05	11	16
rainbow (hatchery)	1				1								2	0	0.03	0.00	19	18
brown trout	3	3	2	7	2				1	2			8	12	0.10	0.21	16	14
brook trout	1												1	0	0.01	0.00	20	18
bull trout														0	0.00	0.00	24	18
lake trout	1												1	0	0.01	0.00	20	18
lake whitefish	3	1							2	1	30	21	35	23	0.45	0.40	14	13
mountain whitefish	161	81	37	34	27		1	2	4	7	38	47	268	171	3.41	2.96	7	9
peamouth	418	58	200	79	164	11	4	15	29	138	399	716	1214	1017	15.46	17.62	3	2
northern squawfish	522	362	375	299	304	55	34	42	60	183	112	64	1407	1005	17.92	17.41	2	3
redside shiner	58	206	60	111	35					2	2		155	319	1.97	5.53	8	6
tench	204	68	119	104	178	316	1		5	4	5	17	512	509	6.52	8.82	4	5
longnose sucker	74	5	25	12	32	10		2	2	1	15	43	148	73	1.88	1.26	9	12
largescale sucker	117	126	94	83	108	7	4	8	20	34	21	30	364	288	4.64	4.99	6	7
brown bullhead	117	21	39	13	296	90			3		5	11	460	135	5.86	2.34	5	10
channel catfish	1												1	0	0.01	0.00	20	18
pumpkinseed	9	46	13	72	78	536							100	654	1.27	11.33	10	4
smallmouth bass	1												1	0	0.01	0.00	20	18
largemouth bass	2	12	12	31	6	173							20	216	0.25	3.74	15	8
black crappie	5	4	2	11	53	71							60	86	0.76	1.49	12	11
yellow perch	1453	292	249	317	1155	480	7	5	40	46	62	115	2966	1255	37.77	21.74	1	1
slimy sculpin													0	0	0.00	0.00	24	18
TOTAL	3242	1289	1250	1176	2452	1749	52	74	166	418	691	1066	7853	5772	100	100		

Table 12. Number of fishes sampled by all gear types within each stratum from the Pend Oreille River, Idaho during late highpool (August) 1991 and 1992.

							STRATA						TOTAL		PERCENT COMPOSITION			
		1		2		3		4		5		6						RA
Species	1992	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	_	1992
kokanee salmon	2		3								9		14	0	0.16	0.00	17	18
cutthroat trout	4	1	11								11		26	1	0.30	0.03	14	16
cutthroat (hatchery)													0	0	0.00	0.00	19	18
rainbow trout	37	1	10	3	7								54	. 4	0.62	0.10	13	14
rainbow (hatchery)													0	0	0.00	0.00	19	18
brown trout	10	2			4				2		1		17	2	0.20	0.05	16	15
brook trout													0	0	0.00	0.00	19	18
bull trout											1		1	0	0.01	0.00	18	18
lake trout													0	0	0.00	0.00	19	18
lake whitefish		1	1		4				6	12	15		26	13	0.30	0.33	14	13
mountain whitefish	419	179	41	7	10	7	4		24	16	123	26	621	235	7.13	6.00	5	7
peamouth	168	98	179	82	76	27	19	19	170	84	463	288	1075	598	12.34	15.27	3	2
northern squawfish	345	103	495	286	155	59	121	27	124	26	101	48	1341	549	15.40	14.02	2	3
redside shiner	87	19	753	51	1	8					1		842	78	9.67	1.99	4	10
tench	139	68	12	34	226	137	2		23		39	29	441	268	5.06	6.84	7	6
longnose sucker	83	13	150	7	39	17	1	1	34	5	96	27	403	70	4.63	1.79	8	11
largescale sucker	176	30	173	49	104	12	21	7	38	7	18	10	530	115	6.09	2.94	6	9
brown bullhead	35	11	2	34	157	64		1	11	4	10	12	215	126	2.47	3.22	10	8
channel catfish													0	0	0.00	0.00	19	18
pumpkinseed	28	81	1	17	113	259			3		1		146	357	1.68	9.11	11	5
smailmouth bass													0	0	0.00	0.00	19	18
largemouth bass	55	56	1	55	199	254							255	365	2.93	9.32	9	4
black crappie	27	12		3	47	40			3				77	55	0.88	1.40	12	12
yellow perch	654	411	448	78	1030	424	19	7	390	34	84	126	2625	1080	30.14	27.57	1	1
slimy sculpin				1									0	1	0.00	0.03	19	16
TOTAL	2269	1086	2280	707	2172	1308	187	62	828	188	973	566	8709	3917	100	100		

Table 13. Number of fishes sampled by all gear types within each stratum from the Pend Oreille River, Idaho during drawdown (October) 1991 and 1992.

						STRATA									PERCENT COMPOSITION		RANK	
		1		2		3		4		5		6	TOTAL					
Species	1992	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
kokanee salmon	1												1	0	0.03	0.00	16	18
cutthroat trout	5	3	6	5							1		12	8	0.42	0.31	14	14
cutthroat (hatchery)				2		1							0	3	0.00	0.12	20	16
rainbow trout	5	1		1	2						2		9	2	0.31	0.08	15	17
rainbow (hatchery)													0	0	0.00	0.00	20	18
brown trout		1	1	3									1	4	0.03	0.15	16	15
brook trout			1										1	0	0.03	0.00	16	18
bull trout													0	0	0.00	0.00	20	18
lake trout											1		1	0	0.03	0.00	16	18
lake whitefish			7	26				2	21	34	11		39	62	1.35	2.38	10	8
mountain whitefish	130	47	42	4	2	2					13	3	187	56	6.47	2.15	4	10
peamouth	93	172	235	142	109	70	1	10	174	42	152		764	436	26.45	16.72	2	3
northern squawfish	128	72	236	290	22	78	1	3	57	13	17	2	461	458	15.96	17.56	3	2
redside shiner	10	4	56	71	2								68	75	2.35	2.88	9	6
tench	4	12	6	6	11	16				1	6		27	35	0.93	1.34	12	11
longnose sucker	34	50	7	9	37	38					4		82	97	2.84	3.72	8	5
largescale sucker	50	12	31	45	15	4	1	2	6	6	26		129	69	4.47	2.65	6	7
brown bullhead	21	59	3	8	115	179							139	246	4.81	9.43	5	4
channel catfish													0	0	0.00	0.00	20	18
pumpkinseed	4	4	3	5	22	48							29	57	1.00	2.19	11	9
smalimouth bass													0	0	0.00	0.00	20	18
largemouth bass	9	6	5	5	10	17							24	28	0.83	1.07	13	12
black crappie	13	11	30	6	54	10							97	27	3.36	1.04	7	13
yellow perch	210	291	151	102	432	549			7	1	18		818	943	28.31	36.16	1	1
slimy sculpin				2									0	2	0.00	0.08	20	18
TOTAL	717	745	820	732	833	1012	3	17	265	97	251 4	5	2889	2608	100	100		

Table 14. Observed (okra), expected (exp) and the magnitude of difference (map) between the observed and expected gill net catches for yellow perch, peamouth and northern squawfish sampled during lowpool, refill, early hlghpool, late highpool and drawdown,1991 and 1992.

LOWPOOL

strata	hours fished	Yellow Perch obs	exp	mag	Peamouth obs	exp	mag	Northern Squawfish obs	exp	mag
1	229.1	67	20.6	3.26	78	73.0	1.07	32	29.3	1.09
2	231.7	3	20.8	-6.93	42	73.8	-1.76	28	29.6	-1.06
3	251.4	26	22.6	1.15	72	80.1	-1.11	23	32.2	-1.40
4		0	0.0		0	0.0		0	0.0	
5	254.6	7	22.9	3.27	40	81.1	-2.03	41	32.6	-0.79
6	213.7	3	19.2	0.16	144	68.1	2.12	27	27.3	-1.01
total	1180.4	106	106	1.00	376	376	1.00	151	151	1.00

REFILL

strata	hours fished	Yellow Perch obs	exp	mag	Peamouth obs	exp	mag	Northern Squawfish obs	exp	mag
1	813.2	236	212.7	1.11	425	498.4	0.85	308	224.6	1.37
2	653.1	27	170.8	-6.33	372	400.3	-1.08	306	180.4	1.70
3	9192	519	240.4	2.16	628	563.3	1.11	211	253.8	-1.20
4	178.6	13	46.7	-3.59	10	109.5	-10.95	45	49.3	-1.10
5	428.3	98	112.0	-1.14	48	262.5	-5.47	54	118.3	-2.19
6	838.7	9	219.4	-24.37	865	514.0	1.68	134	231.6	-1.73
total	3831.1	1002	1002	1.00	2348	2348	1.00	1058	1058	1.00

EARLY HIGPOOL

strata	hours fished	Yellow Perch obs	exp	mag	Peamouth obs	exp	mag	Northern Squawfish obs	exp	mag
1	1085.6	597	461.0	1.30	276	446.4	0.62	368	308.2	1.19
2	896.3	542	380.6	1.42	267	368.6	-1.38	343	254.4	1.35
3	837.0	580	355.4	1.63	85	3442	-4.05	127	237.6	-1.87
4	376.1	12	159.7	-13.31	19	154.6	-8.14	76	106.8	-1.40
5	774.4	86	328.8	-3.82	167	318.5	-1.91	243	219.8	1.11
6	726.3	177	308.4'	-1.74	1117	298.7	3.74	176	2062	-1.17
total	4695.6	1994	1994	1.00	1931	1931	1.00	1333	1333	1.00

LATE HIGHPOOL

strata	hours fished	Yellow Perch obs	exp	mag	Peamouth obs	exp	mag	Northern Squawfish obs	exp	mag
1	916.3	821	462.2	1.78	246	361.4	-1.47	195	261.6	-1.34
2	582.5	95	293.8	-3.09	170	229.8	-1.35	322	166.3	1.94
3	740.9	419	373.7	1.12	101	2922	-2.89	165	211.5	-128
4	490.2	26	247.3	-9.51	38	193.3	-5.09	148	139.9	-0.95
5	648.1	424	326.9	1.30	254	255.6	-1.01	150	185.0	-1.23
6	577.1	210	291.1	-1.39	751	227.6	3.30	149	164.7	-1.11
total	3955.1	1995	1995	1.00	1560	1560	1.00	1129	1129	1.00

DRAWDOWN

strata	hours fished	Yellow Perch obs	exp	mag	Peamouth obs	exp	mag	Northern Squawfish obs	exp	mag
1	313.6	233	137.5	1.69	117	129.6	-1.11	112	70.3	1.59
2	454.9	204	199.5	1.02	186	187.9	-1.01	170	102.0	1.67
3	490.7	435	215.2	2.02	164	202.7	-1.24	86	110.0	-1.28
4	116.5	0	51.1		11	48.1	-4.38	4	26.1	-6.53
5	458.3	8	201.0	-25.12	216	189.4	1.14	70	102.7	-1.47
6	213.7	18	93.7	-5.21	152	88.3	1.72	17	47.9	-2.82
total	2047.7	898	898	1.00	846	846	1.00	459	459	1.00

squawfish had the highest selection for stratum 2 (observed > 1.7 expected) and the highest avoidance for strata 5 and 6.

Significant ($P < 0.001$) habitat selectivity was found for yellow perch, peamouth and northern squawfish during early highpool (Table 14). Yellow perch selected strata 3, 2 and 1 in order of preference. Yellow perch avoided strata 5, 4 and 6. Peamouth selected for stratum 6 (observed > 3.7 expected) and avoided other strata during early highpool. Northern squawfish showed the highest selection for stratum 2 (observed > 1.35 expected) and the highest avoidance for strata 1 and 3.

Sampling during late highpool showed significant ($P < 0.001$) habitat selection for yellow perch, peamouth and northern squawfish. Yellow perch showed the strongest selection for stratum 1 (observed > 1.7 expected) followed by stratum 5 and avoided strata 4 and 2 (Table 14). Peamouth selected for stratum 6 (observed > 3.2 expected) and avoided other strata. Northern squawfish selected stratum 2 (observed > 1.9 expected) during late highpool and avoided strata 1 and 3.

During drawdown yellow perch, peamouth and northern squawfish showed significant ($P < 0.001$) differences for habitat selection (Table 14). Yellow perch showed the strongest selection for stratum 3 (observed > 2.0 expected) followed by stratum 4 (observed > 1.6 expected) and they showed the strongest avoidance from strata 4 and 5. Peamouth selected stratum 6 (observed > 1.7 expected) and avoided stratum 4 during drawdown. Peamouth did not show strong selection or avoidance for strata 1, 2, 3 and 5. Northern squawfish selected for stratum 2 (observed > 1.6 expected) followed by stratum 1 (observed > 1.5 expected) and avoided strata 5 and 6.

During drawdown, lowpool and refill when temperatures were low, significant ($P < 0.001$) habitat selections were found with largemouth bass, black crappie, rainbow trout and cutthroat trout, whereas brown trout did not show significant ($P > 0.10$) preference for habitat types (Table 15). Both largemouth bass and black crappie showed the strongest selection for stratum 3 (observed > 2.2 expected-largemouth bass; observed > 2.6 expected-black crappie) followed by stratum 1 (observed > 1.7 and 1.1 expected) with all other strata (2, 4, 5 and 6) having lower observed than expected values. Largemouth bass and black crappie were not sampled from any littoral strata (4, 5 and 6) during this cool period (drawdown, lowpool and refill). Rainbow and cutthroat trout selected stratum 1 (observed > 2.9 expected-rainbow trout; observed > 2.6 expected-cutthroat trout) showing no strong selection or avoidance for other strata.

'During highpool chi-square homogeneity tests showed largemouth bass, black crappie, rainbow trout and cutthroat trout to significantly ($P > 0.001$) select habitat types, whereas brown trout did not show significant ($P > 0.10$) habitat selection (Table 15). Both largemouth bass and black crappie showed strongest selection for stratum 3 (observed > 4.2 expected-largemouth bass; observed > 4.0 expected-black crappie). All other strata had lower observed than expected values with 3 of 251 fish sampled in pelagic waters (strata 4, 5 and 6) during highpool. Rainbow and cutthroat trout selected for stratum 1 (observed > 2.9 expected-rainbow trout; observed > 2.1 expected-cutthroat trout). Pelagic strata 4, 5 and 6 generally were avoided by cutthroat trout except for stratum 6.

Table 15. Observed (obs), expected (exp) and the magnitude of difference (mag) between the observed and expected gill net catches for largemouth bass, black crappie, rainbow trout, cutthroat trout and brown trout sampled during the cooler period (drawdown, lowpool and refill) and warmer period (early and late highpool) during 1991 and 1992.

DRAWDOWN, LOWPOOL AND REFILL

strata	hours fished	largemouth Bass obs	exp	mag	Black Crappie obs	exp	mag	Rainbow Trout obs	exp	mag	Cutthroat Trout obs	exp	mag	Brown Trout obs	exp	mag
1	1355.9	16	9.0	1.77	27	24.6	1.10	12	4.0	2.98	30	11.3	2.65	3	5.2	-1.73
2	1339.6	6	8.9	-1.49	20	24.3	-1.21	1	4.0	-3.99	11	11.2	-1.02	10	5.1	1.95
3	1661.2	25	11.1	2.26	81	30.1	2.69	3	4.9	-1.65	14	13.9	1.01	10	6.4	1.57
4	295.1	0	2.0	0.00	0	5.4	0.00	0	0.9	0.00	0	2.5	0.00	0	1.1	0.00
5	1141.2	0	7.6	0.00	0	20.7	0.00	0	3.4	0.00	0	9.5	0.00	2	4.4	-2.18
6	1266.1	0	8.4	0.00	0	23.0	0.00	5	3.8	1.33	4	10.6	-2.65	2	4.8	-2.42
total	7059.2	47	47.0	1.00	128	128.0	1.00	21	21.0	1.00	59	59.0	1.00	27	27.0	1.00

EARLY AND LATE HIGHPOOL

strata	hours fished	Largemouth Bass obs	exp	mag	Black Crappie obs	exp	mag	Rainbow Trout obs	exp	mag	Cutthroat Trout obs	exp	mag	Brown Trout obs	exp	mag
1	2001.8	19	27.8	-1.46	26	30.3	-1.17	37	12.7	2.91	30	14.1	2.13	8	6.2	1.28
2	1478.8	8	20.5	-2.56	6	22.4	-3.73	8	9.4	-1.18	10	10.4	-1.04	7	4.8	1.52
3	1577.9	93	21.9	4.25	96	23.9	4.02	9	10.0	-1.11	7	11.1	-1.59	6	4.9	1.22
4	866.3	0	12.0	0.00	0	13.1	0.00	1	5.5	-5.51	0	6.1	0.00	0	2.7	0.00
5	1422.5	0	19.7	0.00	3	21.5	-7.18	0	9.0	0.00	0	10.0	0.00	5	4.4	1.13
6	1303.4	0	18.1	0.00	0	19.7	0.00	0	8.3	0.00	14	9.2	1.52	1	4.1	-4.07
total	8650.7	120	120.0	1.00	131	131.0	1.00	55	55.0	1.00	61	61.0	1.00	27	27.0	1.00

Size Structure

The average length of cutthroat trout sampled in Pend Oreille River, Idaho during 1991 and 1992 was 220 mm ranging from 120 to 460 mm (Figure 14). Native cutthroat trout averaged 230 mm whereas hatchery fish averaged 177 mm. The most abundant size class of cutthroat trout sampled was 180-189 mm.

The average length of rainbow trout sampled during 1991 and 1992 was 199 mm ranging from 70 to 560 mm (Figure 14). Native rainbow trout averaged 200 mm whereas hatchery rainbows averaged 168 mm. The most abundant size class of rainbow trout sampled was 170-179 mm.

Eighty brown trout were sampled during 1991 and 1992 averaged 351 mm with lengths ranging from 70 to 730 mm (Figure 15). No large peak size of brown trout was found as fish were distributed throughout all size classes. Five fish were sampled at both the 210-219 mm and 480-489 mm size classes.

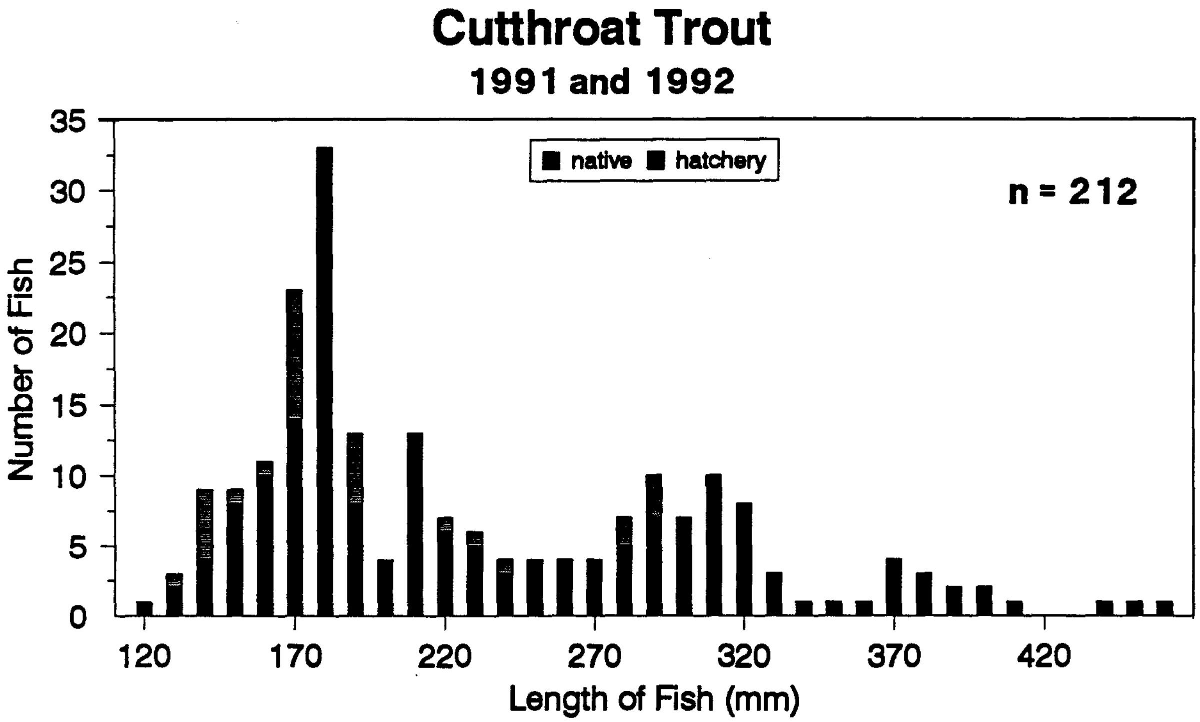
Largemouth bass sampled in Pend Oreille River, Idaho during 1991 and 1992 averaged 124 mm with lengths ranging from 20 to 530 mm (Figure 16). During 1991, 89% of largemouth bass sampled were < 190 mm with an average size of 113 mm . Most of the largemouths sampled during 1991 were in the 40-49 mm size class. During 1992, 91% of the largemouth bass sampled were < 210 mm with an average of 130 mm. A bimodal size distribution of largemouth bass was sampled during 1992 with peaks at 60-69 and 180-189 mm (Figure 16).

Black crappie sampled in Pend Oreille River, Idaho during 1991 and 1992 ranged from 30 to 340 mm with an overall average size of 130 mm (Figure 17). During 1991 the average size of black crappie was 118 mm with one fish > 240 mm. Most crappies sampled during 1991 were around 80 mm . During 1992, the average size of black crappie was 146 mm with the largest peak at 150-159 mm.

Yellow perch sampled in Pend Oreille River, Idaho during 1991 and 1992 ranged from 10 to 320 mm with an overall average size of 126 mm (Figure 18). During 1991 the average yellow perch sampled was 117 mm with peaks at 30-49 and 140-159 mm. Two major size classes were also sampled during 1992 with peak abundance at 60-69 and 140-159 mm.

DISCUSSION

Yellow perch, peamouth and northern squawfish were the most abundant fishes sampled in Pend Oreille River, Idaho representing 64 and 59% of the catch during 1991 and 1992. Chi-square tests indicate individuals of these three species selected different habitat types. Habitat selection of yellow perch generally included strata 1 (along the main river) and 3 (slough) which have small substrate sizes, low velocities, and the highest densities of vegetation of all strata sampled. Habitat selectivity for yellow perch changed with the seasons. During lowpool when the reservoir was drawn down and the sloughs were empty, yellow perch selected for the habitat in stratum 1. As the reservoir filled, yellow perch were widely distributed in littoral habitats showing selection for



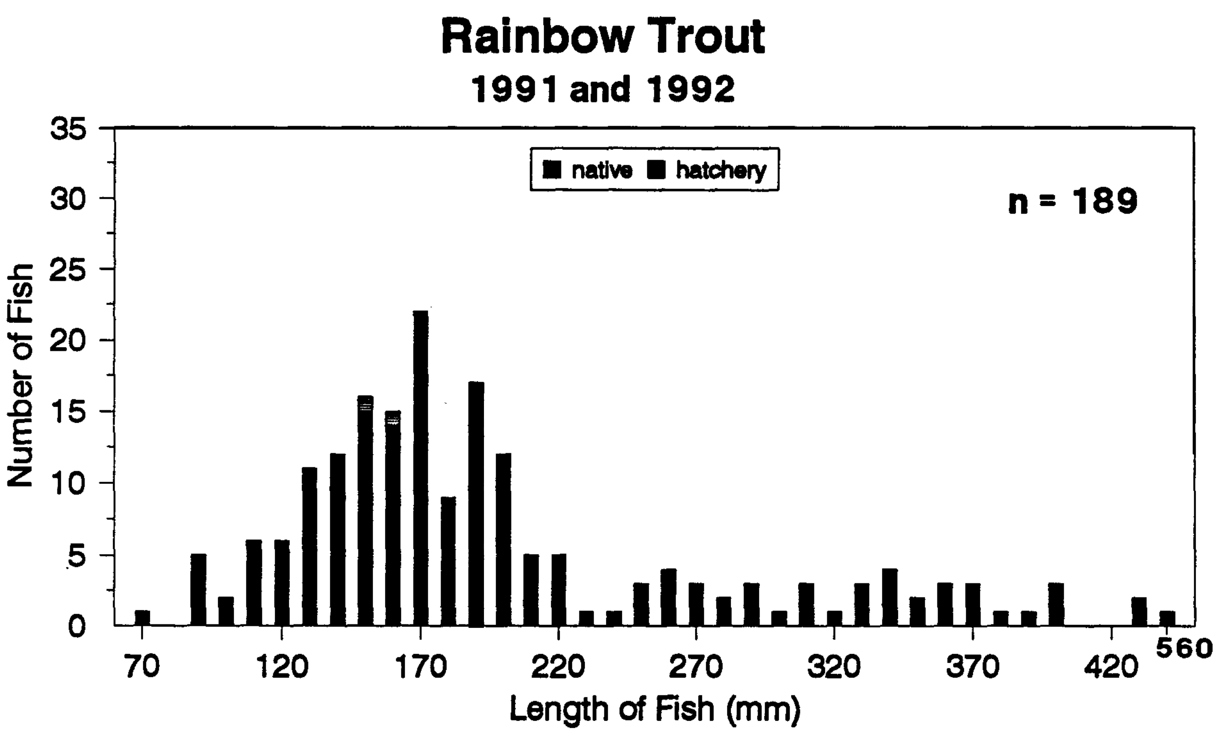


Figure 14. Length (mm) frequency diagram of cutthroat and rainbow trout collected from Pend Oreille River, Idaho during 1991 and 1992.

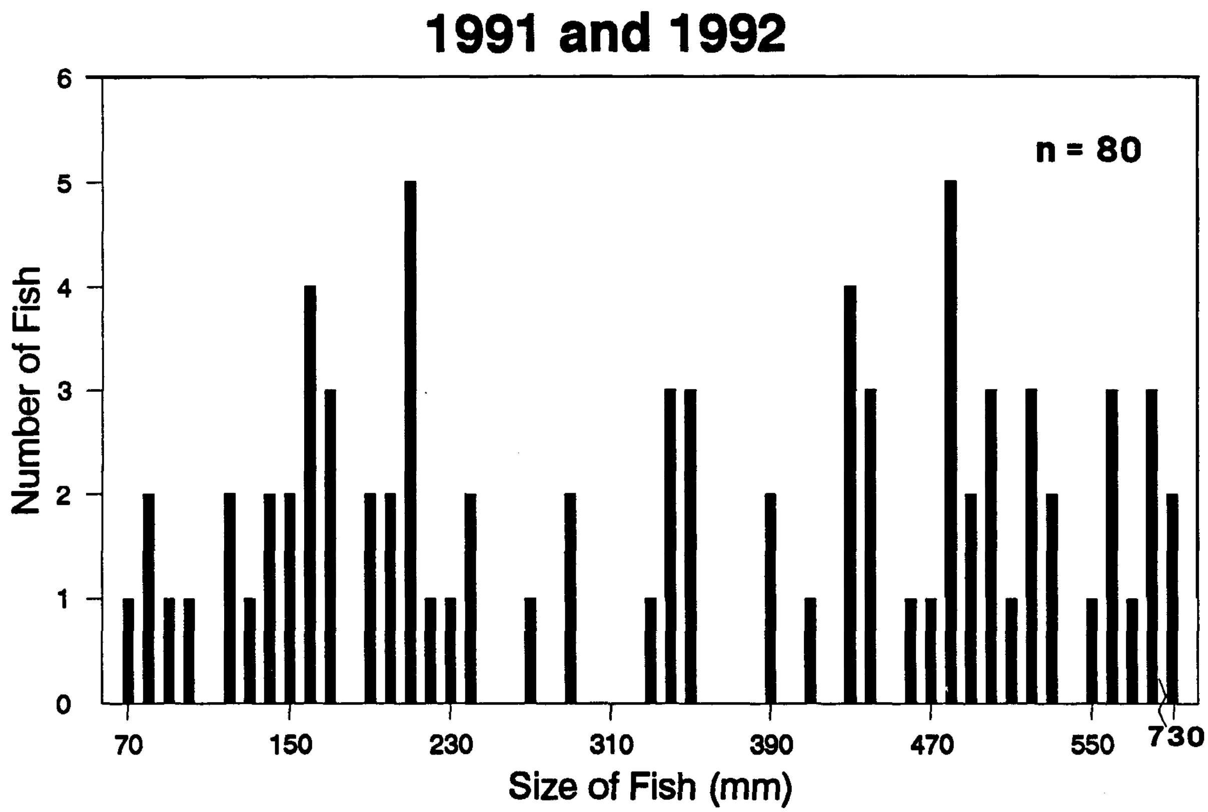


Figure 15. Length (mm) frequency diagram of brown trout collected from Pend Oreille River, Idaho during 1991 and 1992.

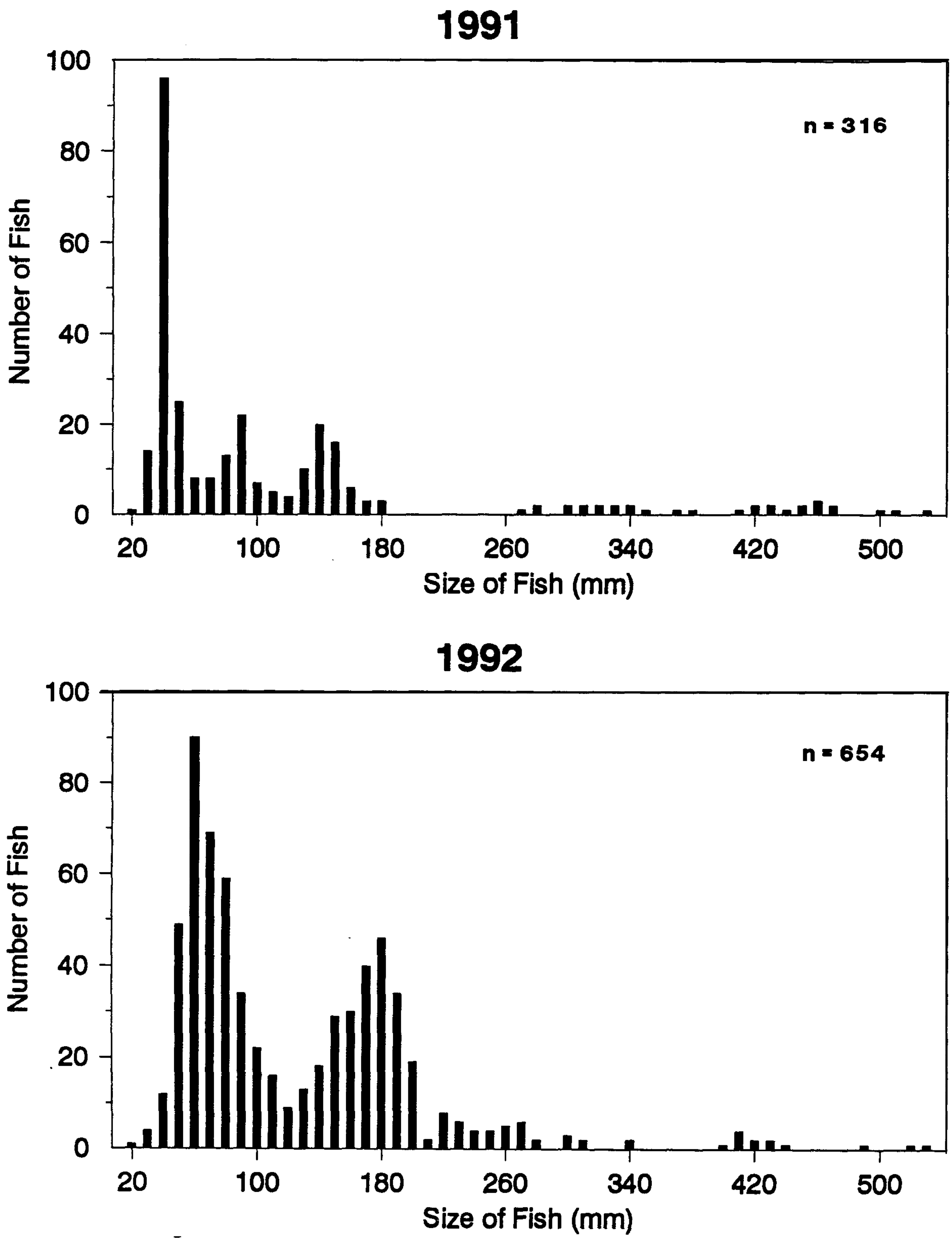


Figure 16. Length (mm) frequency diagrams of largemouth bass collected from Pend Oreille River, Idaho during 1991 and 1992.

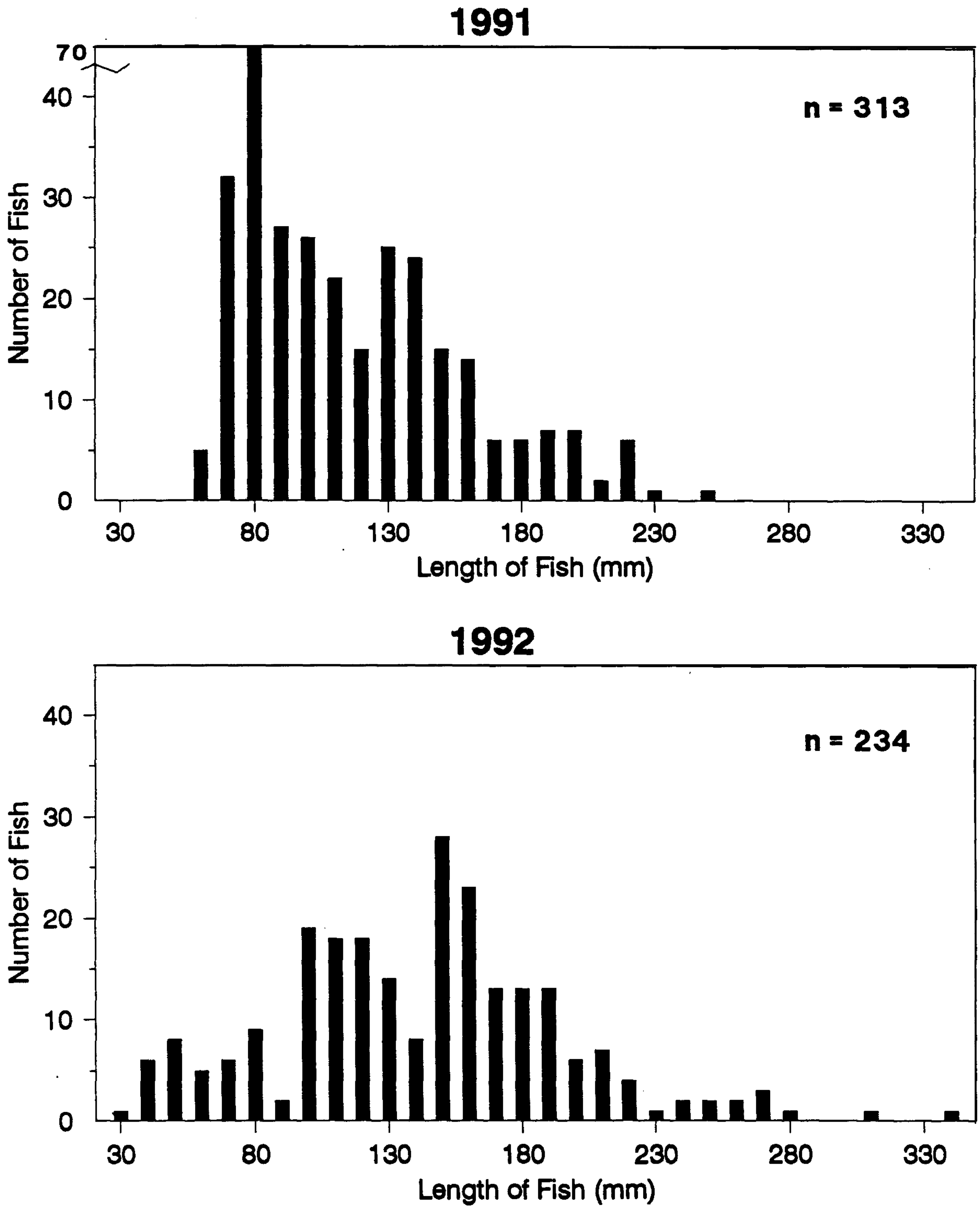


Figure 17. Length (mm) frequency diagram of black crappie collected from Pend Oreille River, Idaho during 1991 and 1992.

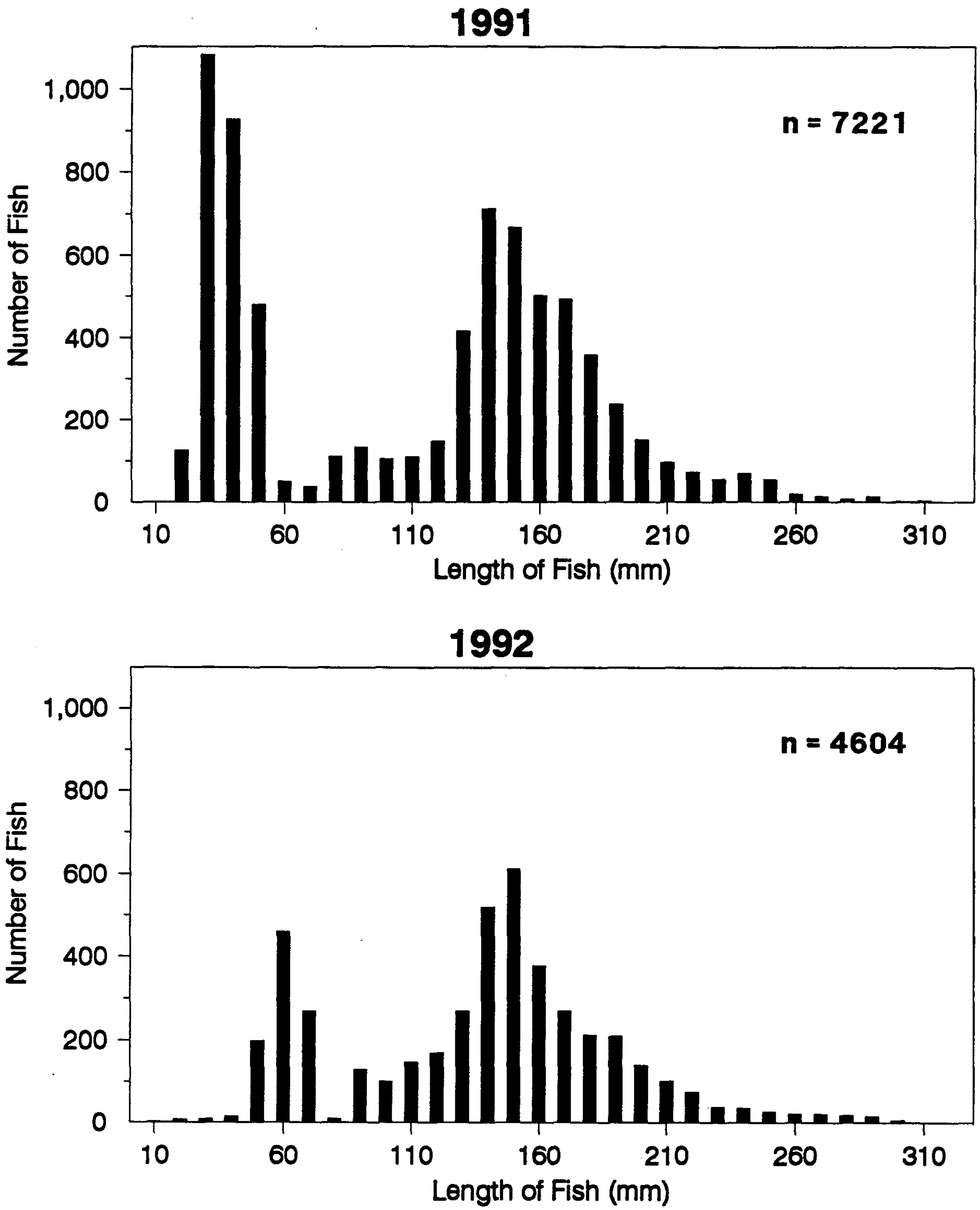


Figure 18. Length (mm) frequency diagram of yellow perch collected from Pend Oreille River, Idaho during 1991 and 1992.

sloughs. During August when velocities were lowest and water temperatures highest, yellow perch expanded their habitation to stratum 1 and pelagic waters of stratum 5. This ability to occupy different habitat types as river characteristics change indicate why yellow perch are probably the dominate species in the Pend Oreille River, Idaho.

Peamouth dominated the catch in the littoral waters of strata 5 and 6 during all stages of drawdown. Peamouth selected highly for stratum 6 which was not selected by either yellow perch or northern squawfish. Stratum 6 is located at the outlet of Pend Oreille Lake.

During lowpool, northern squawfish uniformly occupied all strata. Their ability to inhabit all habitat types during drawdown when water temperatures are lowest suggests how squawfish become abundant in disturbed systems. As temperatures increased, squawfish selected rocky habitats (strata 2 and 4) not selected by yellow perch or peamouth.

Game fishes, excluding yellow perch, of the Pend Oreille River were sampled during 1991 and 1992 at low abundance. The average relative abundance between 1991 and 1992 was 2.1% for largemouth bass, 1.2% for black crappie, and 1.4% for all trout species combined. Because of low fishing pressure on the Pend Oreille River, we believe habitat limitations are responsible for the low relative abundance of game fishes.

Largemouth bass and black crappie showed strong selection for stratum 3 (sloughs) throughout the study and some selection for stratum 1 during the cooler period which includes drawdown, lowpool and refill. Few centrarchids were sampled in pelagic waters. The narrow breadth of habitat selected (stratum 3) by largemouth bass and black crappie suggests why their numbers are low. In addition, sloughs are dewatered to depths < 1 m during lowpool which further decreases their preferred habitat. Habitation of stratum 1 during this period of lower temperatures indicates largemouth bass and black crappie have been forced from the sloughs. Sampling in Box Canyon Reservoir (Objective 5), a system located downriver of Albeni Falls Dam with more stable water levels than Pend Oreille River, showed that largemouth bass and black crappie had stronger selection for sloughs (stratum 3) during the cool (October-June) period than the warm period (June-September). Pitlo (1992) and Sheehan et al. (1990) found that largemouth bass and black crappie in rivers required habitats that consisted of zero velocity and depths > 1.2 m to ensure survival during winter months. These characteristics would typically occur in sloughs in the Pend Oreille River, Idaho without the drawdown. The unusually mild winter and early spring probably increased the survival of largemouth bass which may explain why their relative abundance nearly tripled from 1991 (1.2%) to 1992 (3.3%).

Relative abundance of rainbow and cutthroat trout declined from 1991 to 1992 indicating low survival between the two years, recruitment from the lake in 1992 was lower, and/or habitat conditions were less favorable in 1992. Flows and temperatures were more typical for the Pend Oreille River during 1991 than 1992. Unusually low velocities during spring 1992 did not flush as many fish from the lake as we expected during a typical year.

Catches of rainbow and cutthroat trout decreased as river temperatures increased to > 21°C from mid-July to mid-September. Studies indicate rainbow and cutthroat trout do not flourish at temperatures > 21°C (Everhart and Youngs 1981; Scott and Crossman 1973; Carlander 1969). Highest abundance of rainbow and cutthroat trout was in stratum 1 (littoral with average substrate size < 15 mm), although they did not show strong avoidance for any strata during cool or warm periods. No strong avoidance of habitats suggests that if temperatures were suitable, rainbow and cutthroat trout might be more abundant in the Pend Oreille River as long as suitable spawning and rearing habitat are present.

Catches of brown trout neither changed from 1991 to 1992 nor declined as temperatures increased. These data indicate that brown trout may be year-round residents of the Pend Oreille River and they can tolerate the warmer temperatures. Scott and Crossman (1973) indicate brown trout prefer temperatures ranging from 18.3 to 23.8°C, whereas Carlander (1969) found peak growth occurred at 21°C. Brown trout were distributed uniformly throughout the Pend Oreille River. Habitat of the Pend Oreille River is probably suitable for brown trout as fish sampled exhibited good body condition. Brown trout are also known to thrive in many larger rivers, lakes and reservoirs. Spawning success is probably limiting their numbers as Hoodoo Creek in this section of the river has a population of spawning brown trout. However, spawning in the main river is probably minimal.

Length frequency graphs indicate that few game fishes in the Pend Oreille River reach sizes acceptable to sport fisherman. Larger fish were sampled during 1992 than 1991. The mild winter of 1992 may explain the increase in larger fish. The average length for yellow perch was 126 mm (5 in) in the Pend Oreille River, Idaho. Less than 10% of the yellow perch sampled were > 200 mm (8 in) which is probably the minimal acceptable size for sport fisherman.

Over 90% of largemouth bass sampled were < 200 mm (< 8 in). Fishing for large largemouth bass on the Pend Oreille River is restricted to spring when adults (530 mm/21 in) move into shallow waters for spawning. Low numbers of larger fish indicate high natural mortality (Objective 4). Ashe (1991) reported high emigration with high flows in Box Canyon Reservoir. Hatch (1991) reported that high natural mortality for largemouth bass in Long Lake, Spokane River, Washington possibly due to high emigration as a result of poor overwintering habitat .

Fishing for black crappie also occurs during spring spawning with catches up to 350 mm (14 in). However, our sampling indicates that 85% of crappie are < 180 mm (7 in) and, under present habitat conditions, probably contribute little to the sports fishery in Pend Oreille River, Idaho.

Rainbow, cutthroat and brown trout sizes were more suitable for a fishery. Cutthroat trout as large as 465 mm (18 in) were sampled with 36% of the catches > 250 mm (10 in). Rainbow trout as large as 560 mm (22 in) were sampled with 23% of the catches > 250 mm (10 in). Brown trout as large as 735 mm (29 in) were sampled with 56% of the fish > 330 mm (13 in). However, trout represented < 1% of fish sampled in the Pend Oreille River, Idaho contributing little to the fishery.

Objective 3. To assess food habits of fishes in the Pend Oreille River, Idaho.

METHODS

Stomach contents of yellow perch, northern squawfish, peamouth, largemouth bass, black crappie, rainbow trout, cutthroat trout and brown trout were collected during the 1991 highpool (early and late) sampling period. Stomach contents were collected by lavage or dissection immediately after sampling. Stomach contents of each species were grouped for fishes < 200 mm and > 200 mm. Composite samples were made from at least 20 different fish for each size class. Stomach contents were preserved in 70% ethyl alcohol with 3% glycerol. From each stomach composite, fishes consumed were weighed and identified to species and invertebrates were weighed and identified to order.

Food habits of largemouth bass, black crappie, rainbow trout, cutthroat trout and brown trout were compared with the food habits of yellow perch, peamouth and northern squawfish. Dietary overlaps of these fishes were compared using the equation of Horn (1966):

$$Cx = \frac{2 \sum_{i=1}^{n} (Px_i * Py_i)}{\sum_{i=1}^{n} Px_i^2 + \sum_{i=1}^{n} Py_i^2};$$

where Cx = the overlap coefficient; Px_i = the proportion of food category i in the diet of species x; Py_i = the proportion of food category i in the diet of species of species y; and n = the number of food categories.

Overlap coefficients range from 0 (no overlap) to 1 (complete overlap) with values < 0.3 indicating low overlap and > 0.7 indicating high overlap (Peterson and Martin-Robichaud 1982). We used percent weight consumed for the values of Px_i and Py_i.

If food items were limited in the system, high dietary overlap may indicate competition. When high dietary overlap (Cx > 0.7) occurred between fish species occupying the same habitat, comparisons were made between relative abundance of food items in the diet to relative abundance of those food items in the environment. If food items with high overlap between species were found in low abundance in the environment, competition for food may be occurring.

RESULTS

Food Habits

A total of 162 yellow perch < 200 mm and 140 perch > 200 mm were analyzed for stomach contents (Table 16). Yellow perch < 200 mm fed predominantly on insects as they comprised 56% of the weight of their diet. Insects consumed were trichoptera (21.9%), ephemeroptera (16.5%), diptera (5.3%) and unidentified insect parts (12.2%). Zooplankton represented 12.1% of the food items whereas fish comprised 10.8%. Yellow perch > 200 mm showed a preference for fish followed by insects. Fish represented 48.2% of the stomach contents by weight whereas ephemeroptera, trichoptera and Mvsis relicts represent 20.5%, 11.8% and 5.5% of the stomach contents, respectively.

Stomach contents of 63 northern squawfish < 200 mm were analyzed to determine their feeding behavior (Table 17). Fish were the principle food item (73.4%) with cyprinids > 90% by weight. Insect parts, ephemeroptera and gastropoda represented 16.1%, 7.0% and 2.1% of the diet, respectively. All other organisms represented < 1%. Northern squawfish > 200 mm (n=140) also fed predominantly on fish which represented 83.9% by weight of all food items (Table 17). Of these fishes, 57% were cyprinids and < 2% were salmonids. Crayfish (decapoda), plant material and trichoptera represented 11.7, 1.8 and 1% of the diet, respectively with all other organisms representing < 1%.

Stomachs contents of five peamouth were analyzed for feeding behavior (Table 17). Plant material (62.9%) was the principle food item by weight. Ephemeroptera (30.3%), odonata (3.1%), trichoptera (1.8), gastropoda (1.1%) and diptera (0.9%) represented the remainder of the stomach contents.

Largemouth bass from 100-200 mm (n=25) fed predominantly on fish (93.7%) showing a preference for yellow perch (68%) and brown bullhead Ictalurus nebulosus (14%;) (Table 18). Insect parts represented 2.8% of stomach contents by weight while all other items consumed represented < 1% by weight. Eight largemouth bass > 200 mm showed preference for fish (97.7%) (Table 18). Brown bullhead represented 88% of the fish consumed.

Food habits of black crappie < 200 mm were determined from 33 individuals (Table 18). Insects (37.8) were the preferred food items by weight primarily dipterans (8.1%), ephemeropterans (4.2%) and unknown insect parts (31.9%). Fish (37.8%), zooplankton (10.8%) and leeches (rhyncobdellida, 3.9%) represented the majority of the remaining stomach samples from black crappie < 200 mm. Fish were the dominant food source by weight of black crappie > 200 m (n=9) as they represented 83.6% with cyprinids representing 82.7% of these fish (Table 18). Insects composed 2.6% of the stomach samples by weight; odonata (3.4%) was most abundant. Amphipods were also consumed.

Rainbow trout < 200 mm (n=20) consumed insects (93.5% by weight) (Table 19). Insects were represented mainly by unknown parts (32.1%), hymenoptera (16.4%), ephemeroptera (15.6%) and diptera (12.2%). Zooplankton represented 3.6% by weight. Rainbow trout > 200 mm (n=11) had similar food habits to those < 200 mm, as insects represented 96.6% of the stomach contents. Insects were composed mainly of unknown insect parts (43.0%), ephemeroptera (36.7%) and homoptera (7.5%).

Cutthroat trout < 200 mm (n=14) and > 200 mm (n=22) fed predominantly on insects as they contributed 96.4% and 98.4% of the stomach contents by weight (Table 19). Insects consumed by cutthroat trout < 200 mm were primarily insect parts (37.7%) and ephemeroptera (32.0%). Insects consumed by cutthroat trout > 200 mm were mainly unknown parts (41.7%), hymenoptera (24.5%) and ephemeroptera (21.0%).

Table 16. Stomach contents by weight of yellow perch > 200 mm (n=162) and < 200 mm (n=140) collected during July and August, 1991 from Pend Oreille River, Idaho.

YELLOW PERCH < 200 mm

PREY ITEM	Weight (g)	percent of total weight
TRICHOPTERA (caddisflies)	4.85	21.9
EPHEMEROPTERA (mayflies)	3.65	16.5
INSECT PARTS	2.70	12.2
ZOOPLANKTON	2.68	12.1
FISH	2.39	10.8
DIPTERA	1.18	5.3
MYSIDACEA (mysis shrimp)	1.09	4.9
AMPHIPODA (gammarus shrimp)	1.05	4.8
PLANT MATERIAL	0.78	3.5
OLIGOCHAETA (aquatic earthworms)	0.63	2.8
ODONATA (dragonflies and damselflies)	0.57	2.6
OSTRACODA (seed shrimp)	0.21	1.0
OTHER	0.32	1.5
TOTAL	22.10	100.0

YELLOW PERCH > 200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	27.95	48.2
EPHEMEROPTERA (mayflies)	11.88	20.5
TRICOPTERA (caddisflies)	6.82	11.8
MYSIDACEA (mysis shrimp)	3.19	5.5
INSECT PARTS	3.03	5.2
DECAPODA (crayfish)	2.23	3.9
ODONATA (dragonflies and damselflies)	1.08	1.9
PLANT MATERIAL	0.58	1.0
GASTROPODA (snails)	0.39	0.7
OTHER	0.84	1.4
TOTAL	58.00	100.0

Table 17. Stomach contents of northern squawfish > 200 mm (n=63) and < 200 mm (n=169) and peamouth (all sizes; n=5) collected during July and August, 1991 from Pend Oreille River, Idaho

NORTHERN SQUAWFISH < 200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	15.09	73.4
INSECT PARTS	3.31	16.1
EPHEMEROPTERA (mayflies)	1.45	7.0
GASTROPODA (snails)	0.43	2.1
PLANT MATERIAL	0.17	0.8
ZOOPLANKTON	0.04	02
OTHER	0.06	0.3
TOTAL	20.54	100.0

NORTHERN SQUAWFISH > 200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	599.41	83.9
DECAPODA (crayfish)	83.68	11.7
PLANT MATERIAL	13.02	1.8
TRICHOPTERA (caddisflies)	6.88	1.0
INSECT PARTS	4.55	0.6
EPHEMEROPTERA (mayflies)	3.77	0.5
OTHER	2.71	0.4
TOTAL	714.01	100.0

PEAMOUTH (all size classes)

PREY ITEM	Weight (g)	percent of total weight
PLANT MATERIAL	0.88	62.9
EPHEMEROPTERA (mayflies)	0.42	30.3
ODONATA (dragonflies and damselflies)	0.04	3.1
TRICHOPTERA (caddisflies)	0.02	1.8
GASTROPODA (snails)	0.02	1.1
DIPTERA	0.01	0.9
TOTAL	1.39	100.0

Table 18. Stomach contents by weight of largemouth bass 100-200 mm (n=25) and > 200 mm (n=8) and black crappie < 200 mm (n=33) and > 200 mm (n=9) collected during July and August, 1991 from Pend Oreille River, Idaho.

LARGEMOUTH BASS 100-200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	11.77	93.7
INSECT PARTS	0.36	2.8
ODONATA (dragonflies and damselflies)	0.11	0.9
COLEOPTERA (beadles)	0.10	0.8
EPHEMEROPTERA (mayflies)	0.10	0.8
AMPHIPODA (gammarus shrimp)	0.07	0.6
OTHER	0.05	0.4
TOTAL	12.56	100.0

LARGEMOUTH BASS > 200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	13.68	97.7
PLANT MATERIAL	0.32	2.3
DIPTERA	<0.01	<0.1
TOTAL	13.99	100.0

BLACK CRAPPIE < 200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	1.58	37.8
INSECT PARTS	1.34	31.9
ZOOPLANKTON	0.45	10.8
DIPTERA	0.34	8.1
EPHEMEROPTERA	0.18	4.2
RHYNCOBDEWDA	0.16	3.9
PLANT MATERIAL	0.08	1.8
AMPHIPODA (gammarus shrimp)	0.05	1.1
OTHER	0.02	0.4
TOTAL	4.19	100.0

BLACK CRAPPIE > 200 mm

PREY ITEM	Weight (g)	percent of total weight
FISH	5.19	83.6
AMPHIPODA	0.25	4.0
ODONATA	0.21	3.4
INSECT PARTS	0.16	2.6
EPHEMEROPTERA	0.12	2.0
PLANT MATERIAL	0.10	1.6
DIPTERA	0.10	1.6
OTHER	0.08	1.2
TOTAL	6.20	100.0

Brown trout (n=10) ranging from 80 to 730 mm fed almost exclusively on fish representing 99.6% of the food items by weight (Table 19). Salmonids represented 29% (by weight) of the fish consumed whereas nonsalmonids represented 71%. Of the nonsalmonids, 53% were cyprinids, 43% were unidentifiable and 4% were yellow perch by weight.

Diet Overlap

Based on percent of prey item consumed by weight, 49% of the fish groupings had low diet overlaps whereas 31% had high diet overlaps (Table 20). Fishes that consumed mostly insects had low dietary overlaps whereas fishes that consumed mostly fish had high diet overlaps. No game species had high dietary overlaps (> 0.7) with yellow perch < 200 mm, whereas both size classes of largemouth bass and black crappie had high overlaps with yellow perch > 200 mm. Brown trout also had a high dietary overlap with yellow perch > 200 mm. Brown trout, both size classes of largemouth bass, and black crappie > 200 mm had high dietary overlaps with all sizes of northern squawfish. No fishes had high dietary overlaps with peamouth. Rainbow and cutthroat trout did not have high dietary overlaps with yellow perch, northern squawfish, or peamouth.

Species with high dietary overlaps that occupy similar habitats are largemouth bass and yellow perch, black crappie and yellow perch, brown trout and yellow perch, and brown trout and northern squawfish. Most fishes consumed by yellow perch were unidentifiable. Black crappie showed a preference for cyprinids and largemouth bass consumed mostly yellow perch and brown bullheads.

Most diet overlap occurred in the sloughs. Sampling in sloughs showed cyprinids (35%), yellow perch (44%) and brown bullhead (10%) were the most numerous fishes indicating that these fishes would not be a limiting prey source for black crappie and largemouth bass. Both northern squawfish and brown trout fed heavily on cyprinids; however, cyprinids were the most abundant fish (49%) in the Pend Oreille River, Idaho which is probably related to their high incidence in diets of predators.

DISCUSSION

The most abundant fishes of the Pend Oreille River, Idaho displayed different food habits. Yellow perch consumed insects, fish and zooplankton. Northern squawfish fed predominantly on fish with smaller quantities of insects and crayfish, and peamouth fed almost exclusively on insects. Differences in diet minimize interactions for food and possibly explains why these fishes have proliferated in numbers.

Concern has risen that yellow perch, northern squawfish and peamouth may be out competing game fishes for food or actually preying on them causing reduced numbers (Ashe 1991). Comparison of diet overlap (Horn 1966) between selected game fishes and the most abundant fishes indicate high overlap. In each case, high diet overlap was a result of all species feeding predominantly on fish. Selection of prey items that are limited in number may indicate that competition is occurring. Largemouth bass, black crappie and brown trout fed on the most numerous fishes in the system which indicates competition is not occurring. Also, high relative weights of largemouth bass, black crappie and brown trout also indicate food is not limited (Objective 4).

Table 19. Stomach contents by weight of rainbow (n-31) and outth oat (n=36) trout < 200 mm and > 200 mm and all sizes of brown trout (n=10) collected during July and August, 1091 from Pend Oreille River, Idaho.

RAINBOW TROUT < 200 mm n=20		
PREY ITEM	Weight (g)	percent of trial weight
INSECT PARTS	2.45	32.1
HYMENOPTERA (ant and bees)	1.25	16.4
EPHEMEROPTERA (mayflies)	1.19	15.6
DIPTERA	0.93	12.2
HOMOPTERA (leaf hoppers)	0.89	11.6
TRICHOPTERA (caddisflies)	0.32	42
ZOOPLANKTON	0.28	3.6
COLEOPTERA (beetles)	0.10	1.4
OTHER	0.23	3.0
TOTAL	7.64	100.0

RAINBOW TROUT > 200 mm n=11		
PREY ITEM	Weight (g)	percent of total weight
INSECT PARTS	3.25	43.0
EPHEMEROPTERA (mayflies)	2.77	36.7
HOMOPTERA (leaf hoppers)	0.57	7.5
COLEOPTERA (beetles)	0.37	4.9
HYMENOPTERA (ants)	024	32
ARANEAE (spiders)	0.20	2.6
DIPTERA	0.10	1.3
OTHER	0.06	0.8
TOTAL	7.55	100.0

CUTTHROAT TROUT < 200 mm n=14		
PREY ITEM	Weight (g)	percent of total weight
INSECT PARTS	5.16	37.7
EPHEMEROPTERA (mayflies)	4.38	32.0
HOMOPTERA (leaf hoppers)	1.51	11.0
COLEOPTERA (beetles)	0.99	7 2
HYMENOPTERA (ants and bees)	0.73	5.4
DIPTERA	024	1.7
FISH	0.21	1.5
HEMIPTERA (true bugs)	0.20	1.4
OTHER	0.28	2.1
TOTAL	13.69	100.0

CUTTHROAT TROUT > 200 mm n=22		
PREY ITEM	Weight (g)	percent of total weight
INSECT PARTS	12.65	41.7
HYMENOPTERA (ants and bees)	7.42	24.5
EPHEMEROPTERA (mayflies)	6.38	21.0
DIPTERA	1.98	6.5
TRICHOPTERA (caddis flies)	0.81	2.7
HEMIPTERA (true bugs)	0.49	1.6
COLEOPTERA (beetles)	0.35	1 2
HOMOPTERA (leaf hoppers)	0.23	0.8
OTHER	0.48	1.6
TOTAL	30.31	100.0

BROWN TROUT (all size classes) n=10		
PREY ITEM	Weight (g)	percent of total weight
FISH	61.40	99.6
HYMENOPTERA (true bugs)	0.24	0.4
DIPTERA	0.00	<0.1
TOTAL	61.64	100.0

Table 20. Dietary overlap of selected game. species including largemouth bass (MSA), black crapppie (PNI), rainbow trout (OMY), cutthroat tout (OCL) and brown trout (STR) with the most abundant game species (yellow perch, PFL; northern squawfish, POR; and peamouth, MCA) of the Pend Oreille River, Idaho. Overlap coefficients < 0.3 Indicate low overlap whereas > 0.7 indicates high diet overlap.

	Game Species of Concern								
Most abundant species	MSA 100 -200 mm	MSA >200 mm	PNI <200 mm	PNI >200 mm	OMY <200 mm	OMY >200 mm	OCL <200 mm	OCL >200 mm	STR
PFL<200mm	0.21	0.20	0.54	0.24	0.54	0.50	0.52	0.46	0.19
PFL > 200 mm	0.77	0.75	0.74	0.82	0.22	0.31	0.33	0.24	0.75
POR < 200 mm	0.96	0.94	0.79	0.97	0.17	0.21	0.23	0.19	0.94
POR < 200 mm	0.98	0.98	0.65	0.99	0.01	0.01	0.03	0.01	0.98
MCA	<0.01	0.02	0.07	0.03	0.15	0.27	0.26	0.17	<0.01

Rainbow and cutthroat trout did not have high diet overlaps with yellow perch, northern squawfish, or peamouth. Less than 4% of the fish consumed by northern squawfish were salmonids. During 1991, salmonids comprised > 8% of the fishes sampled in the Pend Oreille River suggesting northern squawfish are not selecting salmonids as food items. Our results indicate that high squawfish abundance is not directly related to the low numbers of rainbow or cutthroat trout in the Pend Oreille River.

Objective 4. To determine and compare age, growth and mortality of selected game fishes in Pend Oreille River, Idaho with other systems of the same latitude.

METHODS

Scales, total lengths and weights were collected from selected games fishes (yellow perch, largemouth bass, black crappie and brown trout) sampled by gill netting, electrofishing and beach seining. Scale samples were obtained at the posterior extension of the pectoral fin for yellow perch, largemouth bass and black crappie and between the dorsal fin and lateral line for brown trout (Nielsen and Johnson 1983). Scales were pressed on acetate slides and projected with a Ken-a-Vision projector onto a Houston Instruments HiPad digitizing tablet. Fish age was determined by counting the number of annuli on each scale. Distances between the focus and annuli were digitized and the computer program DISBCAL computed mean length at age (Frie 1982). The program computes length at age using the Fraser Lee method (Carlander 1981). This method assumes a direct relationship between scale and body growth throughout the life of a fish (Everhart and Youngs 1981; Nielsen and Johnson 1983). Growth rates of fishes were compared within similar systems (Carlander 1969 and 1977; Ashe 1991; Bennett and Liter 1991; Hatch 1991).

The relative weight factor was calculated using weight-length relationships (Wedge and Anderson 1979). Relative weight factor is calculated by (Anderson 1980; Murphy et al. 1991):

$$W_r = (W/W_s) \times 100;$$

where W, = relative weight; W = weight of the fish; W, = a length-specific standard weight defined as log W, = -5.386 + 3.230, log L (yellow perch), log W, = -5.528 + 3.273, log L (largemouth bass), log W, = -5.618 + 3.345, log L (black crappie); and L = length of fish.

Instantaneous mortality (Z) for yellow perch, largemouth bass, black crappie and brown trout were determined by catch curves (Ricker 1975). Catch curves were constructed by graphing the natural log (ln) of the catch as a function of age and instantaneous mortality was estimated by the absolute value of the slope of the descending right limb. Instantaneous mortality can be used to determine annual survival (S) by:

$$S = e^{-Z};$$

where Z = instantaneous total mortality, S = annual survival, and A = annual mortality or 1-S.

RESULTS

Growth

Eighty-two scales from yellow perch ranging from 76 to 314 mm were used to determine length at age. Yellow perch ranged from age-0 to 8 with gradual continual growth between each age class (Figure 19). Growth increments generally

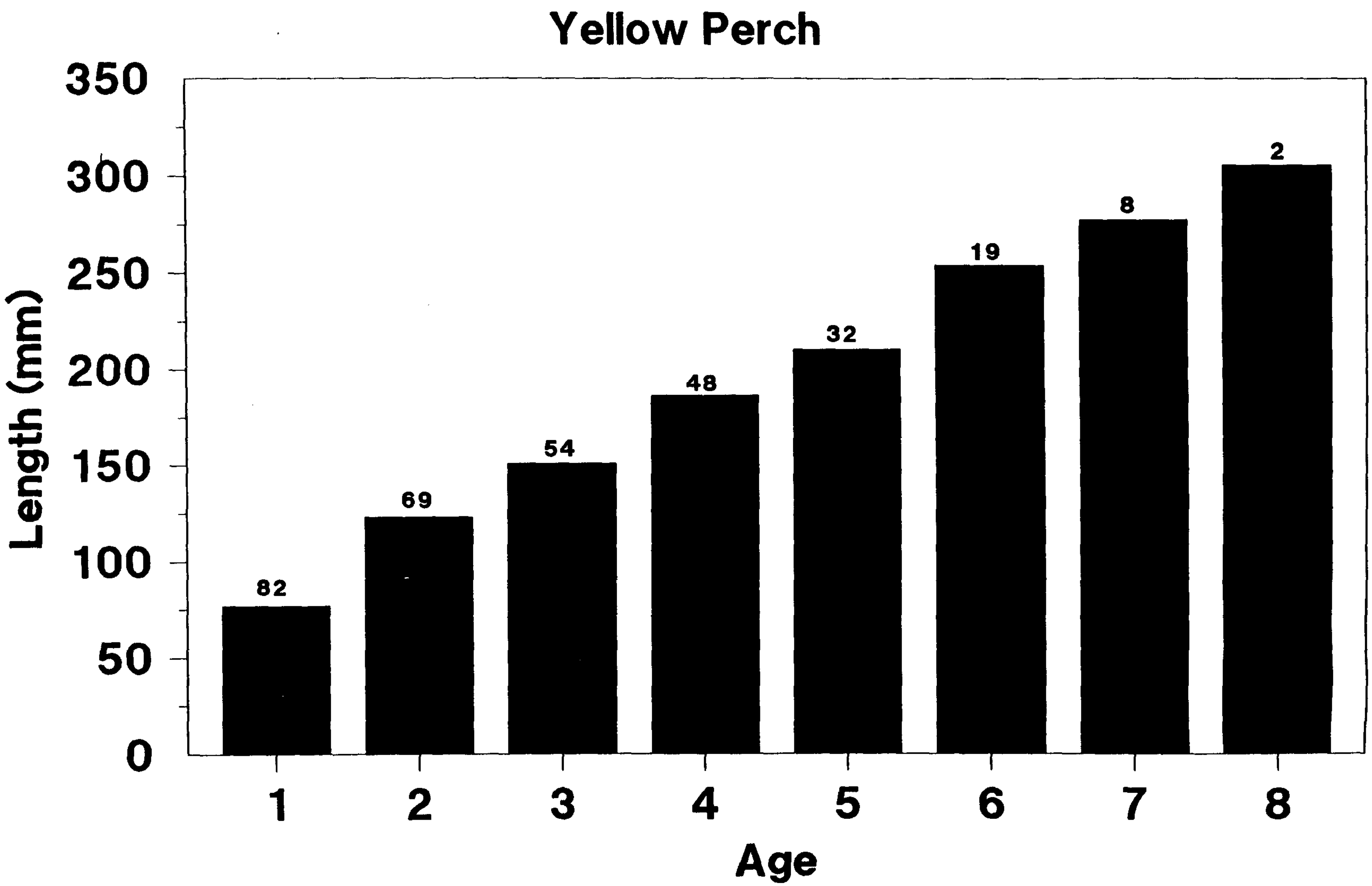


Figure 19. Back-calculated length at age for yellow perch in Pend Oreille River, Idaho. Numbers over bars indicate how many fish were analyzed from each age class.

decreased with increasing age. At age 1 the average back calculated length for yellow perch was 77 mm. At age 5 yellow perch averaged > 200 mm (8 in) and at age 8 they exceeded 300 mm (12 in).

Growth rates of yellow perch from Pend Oreille River, Idaho were higher than in Box Canyon Reservoir and similar to Long Lake, Washington (Table 21). Yellow perch from Box Canyon Reservoir and the Pend Oreille River, Idaho have similar sizes at age 1, but by age 5 yellow perch from the Pend Oreille River average 46 mm longer than perch from Box Canyon Reservoir. Growth rates of yellow perch from Long Lake, Washington were higher at younger ages (1-5) than in Pend Oreille River, but by age 6 yellow perch from both systems averaged around 250 mm.

Weights of yellow perch increase exponentially as length increases with the largest weight gains occurring in longer fish (Figure 20). A mean W_r of 77% was calculated for yellow perch > 100 mm sampled from the Pend Oreille River, Idaho.

Back-calculated length at age for largemouth bass (n=125) showed fish from age-0 to 12 with lengths ranging from 59 to 538 mm. Length increments are highest for age 1 to 3 and were generally large up to age 6 (Figure 21). The average length for age 1 largemouth bass is 85 mm with fish exceeding 300 mm (12 in) by age 5. Age 6 largemouth bass lengths averaged > 400 mm (16 in).

Largemouth bass in the Pend Oreille River, Idaho grow faster than other largemouth bass stocks in northern Idaho and northwest Washington (Table 22). Bass from Long Lake, Washington had higher growth rates at ages 1-6, however after they reached age 7 their average sizes were similar in both systems.

Weights of largemouth bass from Pend Oreille River increased exponentially as lengths increased; the heaviest weight occurred at 500-530 mm (Figure 22). Largemouth bass with an average length of 515 mm (20.3 in) had an average weight of 2,575 g (5.7 lbs). Comparison of mean weights of bass > 150 mm between the Pend Oreille River and studies across North America (Murphy et al. 1991) revealed a W_r of 112%.

Fifty-two black crappie 105 to 344 mm were analyzed to determine length at age (Figure 23). The oldest black crappie was age 7. The longest growth increment occurred from age-0 to 1 with a slight decline following each year. Black crappie lengths averaged 78 mm after the first year and at age 3 averaged nearly 200 mm (8 in). At age 6 black crappie exceeded 300 mm (12 in).

Age at length for black crappie from Pend Oreille River, Idaho was similar to the average for western waters, however age at length was considerably higher compared to Box Canyon Reservoir and Montana lakes (Table 23).

Weights of black crappie from Pend Oreille River, Idaho increased exponentially as lengths increased. The largest weight increases occurred between the longest size groups (Figure 24). Black crappie with an average length of 259 mm (10 in) had an average weight of 291 g (0.64 lbs). Comparison of the average black crappie weight > 100 mm between the Pend Oreille River and studies across their range (Murphy et al. 1991) revealed a W_r of 107%.

Scale analysis of brown trout (n=59) ranging from 80 to 737 mm showed they were age-0 to 7 (Figure 25). The largest growth increment occurred during the first 2 years and from age 6 to 7. Age 1 fish averaged 110 mm in length and were 225 mm by age 2. At age 5, the average length of brown trout increased to 524 mm.

Brown trout from the Pend Oreille River, Idaho had growth rates that were considerably higher than in Box Canyon Reservoir and the U.S. average for streams (Table 24). The average length at age for U.S. lakes was lower than in the Pend Oreille River, Idaho.

Table 21. Comparison of length at age for yellow perch populations in lakes and reservoirs in northern Idaho and northeastern Washington.

Location and Citation	I	II	III	IV	V	VI	VII
Pend Oreille River, Idaho	77	123	151	186	210	253	277
Box Canyon, Washington Ashe (1991)	75	114	135	151	164	194	197
Long Lake, Washington Hatch (1991)	86	146	195	227	244	256	264

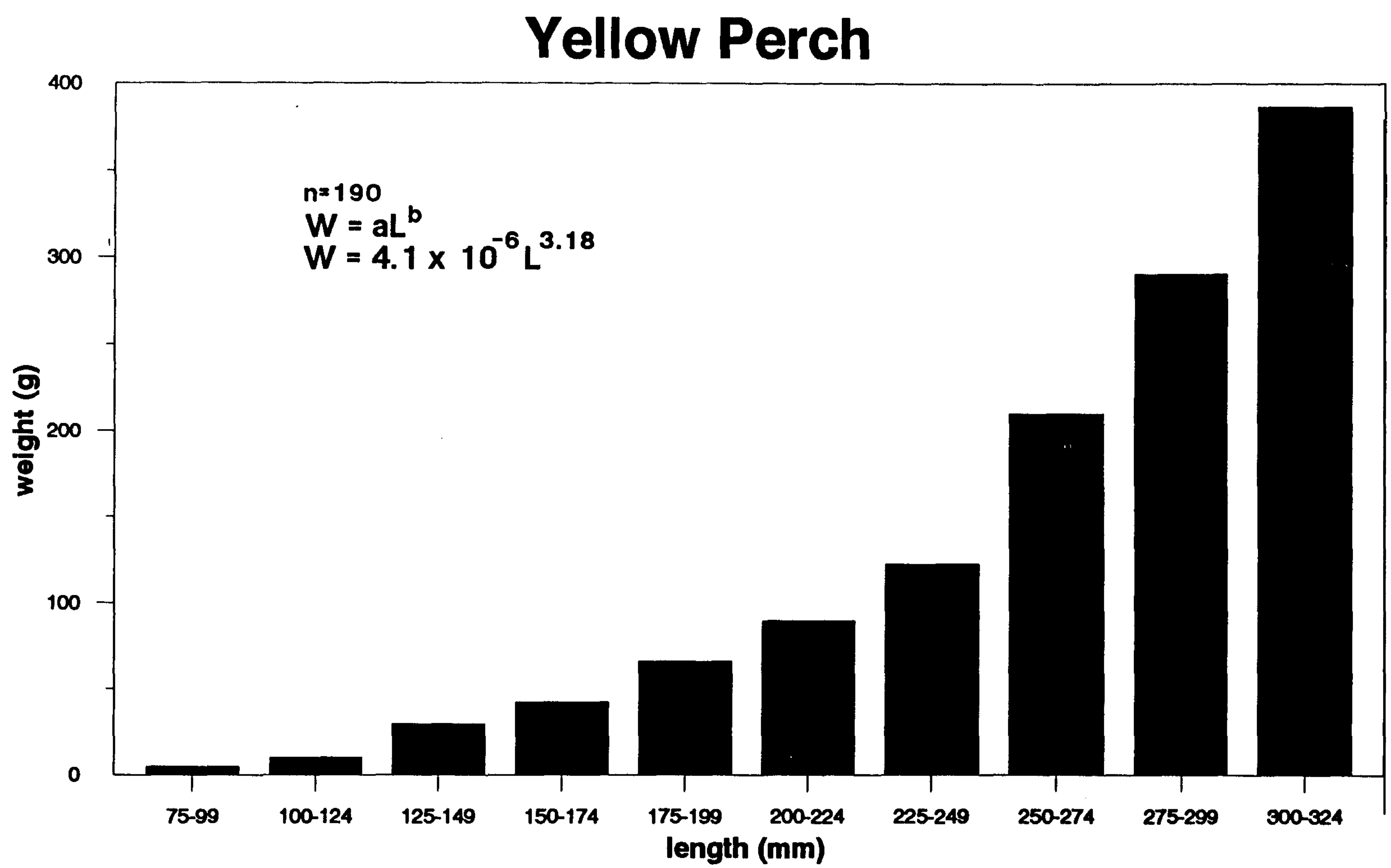


Figure 20. Weight (g) as a function of length (mm) for yellow perch from Pend Oreille River, Idaho. No fish were weighed from 200 to 249 mm.

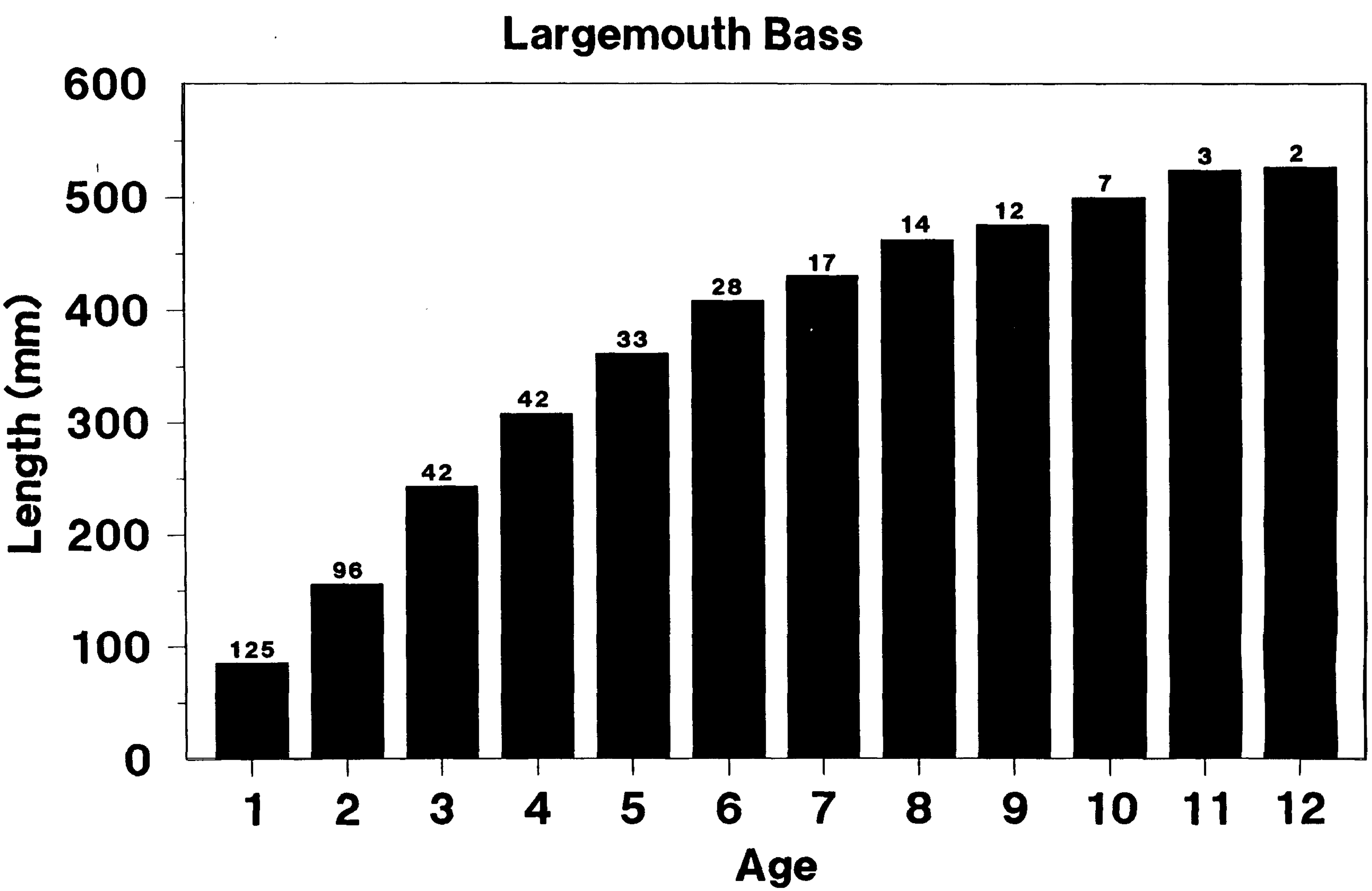


Figure 21. Back-calculated length at age for largemouth bass in Pend Oreille River, Idaho. Numbers over bars indicate how many fish were analyzed from each age class.

Table 22. Comparison of length at age for largemouth bass populations in lakes and reservoirs in northern Idaho and northeastern Washington.

Location and Citation	I	II	III	IV	V	VI	VII	VIII	IX	X
Pend Oreille River, Idaho	85	156	243	307	361	408	431	462	475	499
Box Canyon, Washington Liter (1991)	82	159	227	296	339	370	395	399	405	421
Thompson Lake, Idaho Rieman (1983)	69	139	212	277	325	372	408	440	466	482
Fernan Lake, Idaho Rieman (1983)	63	101	182	230	276	342	374	404	432	460
Long Lake, Washington Hatch (1991)	110	209	289	345	387	414	435	455	470	502

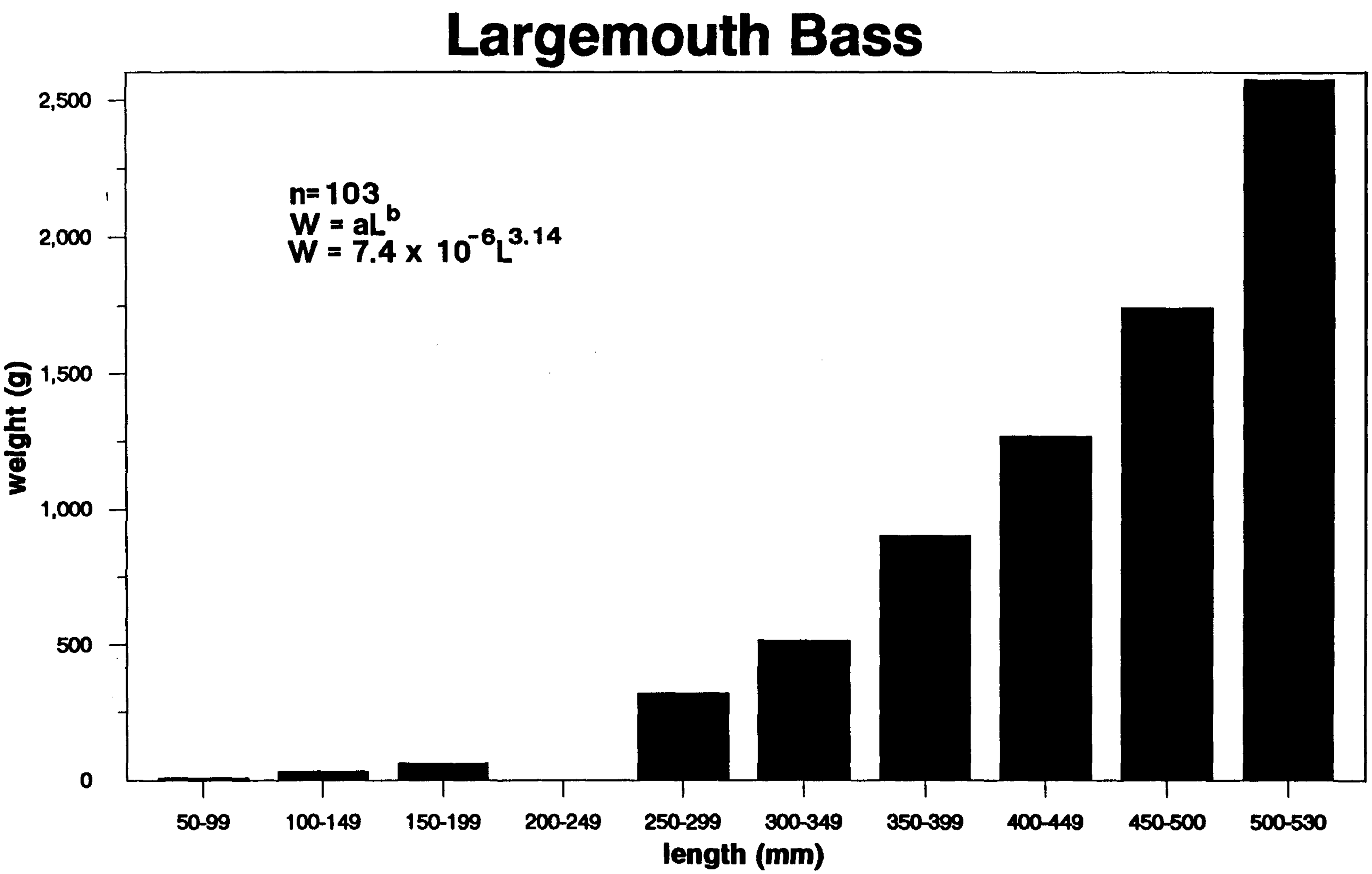


Figure 22. Weight (g) as a function of length (mm) for largemouth bass from Pend Oreille River, Idaho. No fish were weighed from 200 mm to 249 mm.

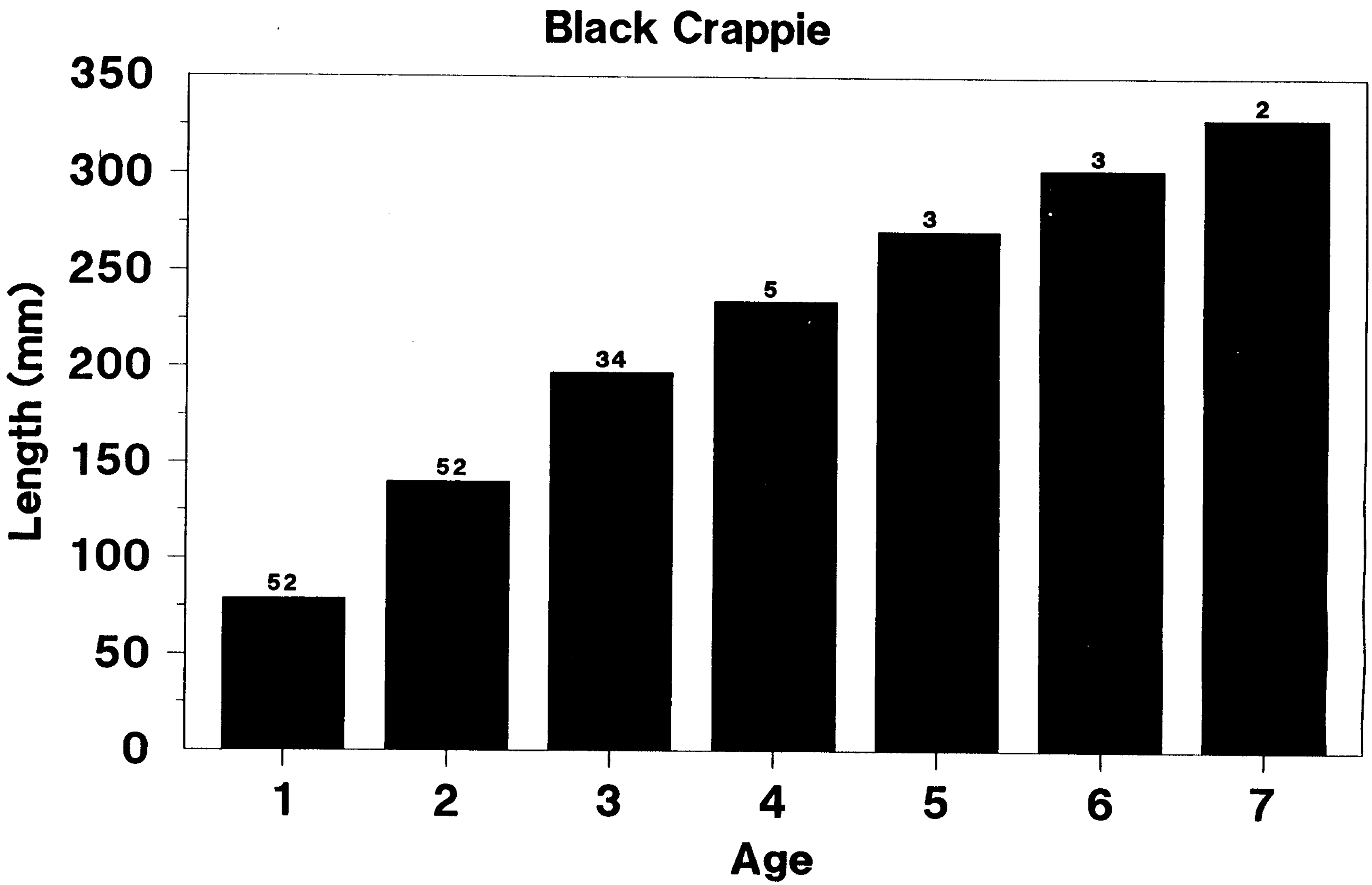


Figure 23. Back-calculated length at age for black crappie in Pend Oreille River, Idaho. Numbers over bars indicate how many fish were analyzed from each age class.

Table 23. Comparison of length at age for black crappie populations in lakes and reservoirs from the Northwest.

Location and Citation	I	II	III	IV	V	VI	VII
Pend Oreille River, Idaho	79	140	197	234	270	302	329
Box Canyon, Washington Ashe (1991)	69	102	136	165	187	206	215
Montana lakes Carlander (1977)	84	135	170	198	213	211	206
Mean for western waters Carlander (1977)	85	156	206	234	241	201	192

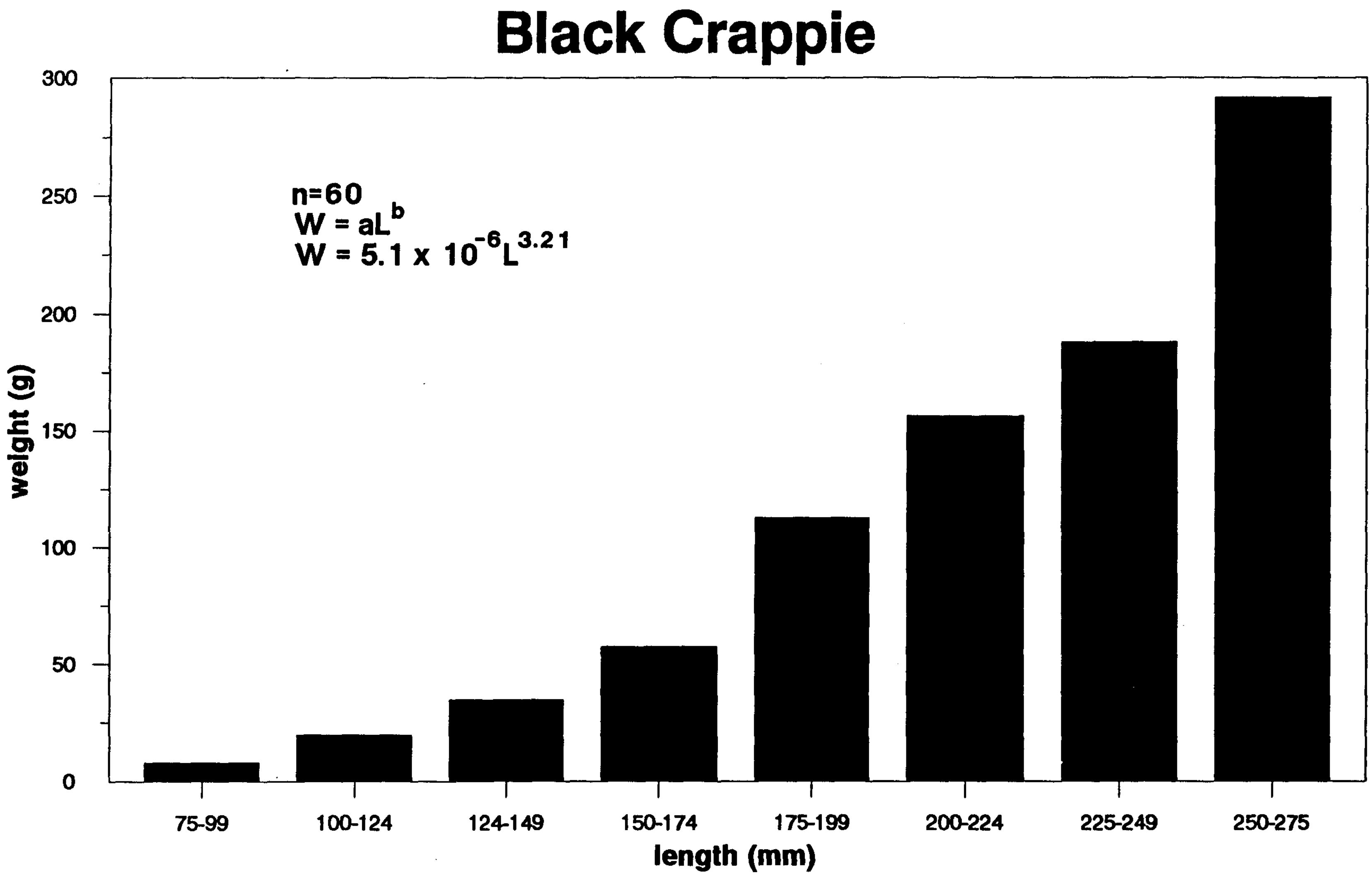


Figure 24. Weight (g) as a function of length (mm) for black crappie from Pend Oreille River, Idaho.

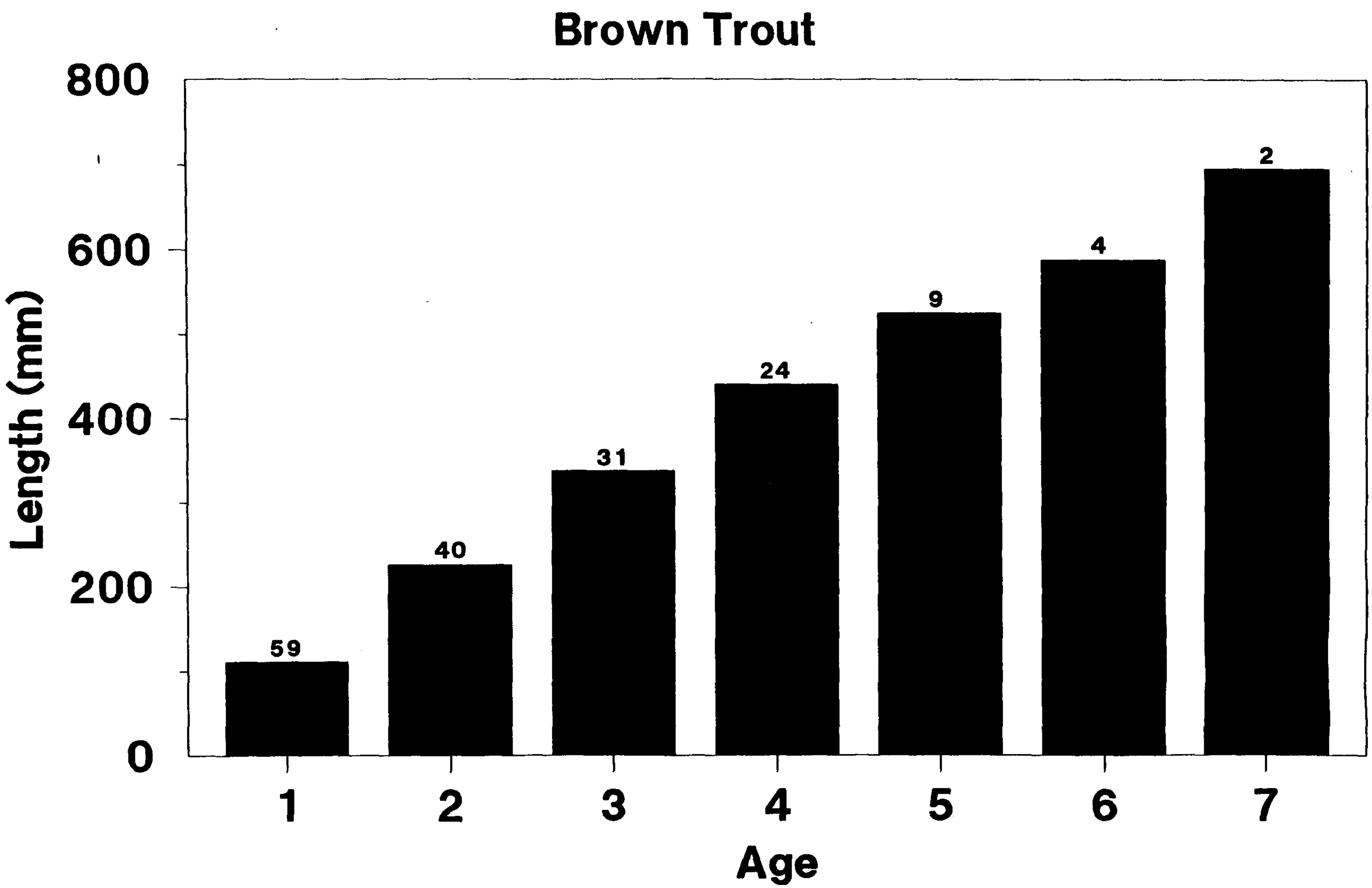


Figure 25. Back-calculated length at age for brown trout in Pend Oreille River, Idaho. Numbers over bars indicate how many fish were analyzed from each age class.

Table 24. Comparison of length at age for brown trout populations in lakes, streams and reservoirs across the United States.

Location and Citation	I	II	III	IV	V	VI	VII
Pend Oreille River, Idaho	110	226	338	440	525	588	696
Box Canyon, Washington Ashe (1991)	89	155	229	300	365	397	454
Mean for U.S. streams Carlander (1969)	97	203	282	348	445	495	551
Mean for U.S. lakes Carlander (1969)	107	216	333	394	513	584	605

Brown trout up to 737 mm (29 in) and 5,360 g (11.8 lbs) were sampled in the Pend Oreille River, Idaho (Figure 26). The largest weight gain was between the longest size classes. Brown trout < 350 mm from the Pend Oreille River weighed less than the world average whereas brown trout > 450 mm were heavier than the world average (Carlander 1969).

Mortality

Estimated instantaneous total mortality for yellow perch from ages 3 to 8 was 1.068 and 0.9057 in 1991 and 1992 (Figure 27). These instantaneous mortalities convert to annual mortality (A) rates of 66 (1991) and 60% (1992) and therefore, annual survival (S) rates of 34 (1991) and 40% (1992).

Instantaneous total mortality was calculated for largemouth bass between the ages of 1 and 4 (Figure 28). During 1991, Z = 1.162 and during 1992 Z = 1.151 which converts to annual mortality rates of 69 and 68%. Annual survival was then 31% in 1991 and 32% in 1992.

Estimated instantaneous total mortality rates for black crappie were similar to largemouth bass at Z = 1.214 during 1991 and Z = 0.913 during 1992 (Figure 29). These values convert to annual mortality rates of 70 (1991) and 60% (1992) and annual survival rates of 30% in 1991 and 40% in 1992.

DISCUSSION

Growth

Growth rates of yellow perch from Pend Oreille River, Idaho are comparable to other systems in northern latitudes (Hatch 1991; Liter 1991). An increase in length through all age classes allows yellow perch to reach suitable size for fishing (250 mm/9 in) by age 6, although the oldest yellow perch sampled was age 8 and > 310 mm (12.5 in).

A relative weight of 77% indicates that yellow perch from the Pend Oreille River are not as heavy as the average yellow perch in the U.S. Low relative weights may indicate high perch numbers, a density dependent response, and possibly less than optimum temperatures. Hokanson (1977) reported a final preferred temperature of 27°C for yellow perch, about 5°C higher than summer temperatures in the Pend Oreille River. The largest yellow perch were sampled below Long Bridge. Fish in this area were feeding on Mysis shrimp and Hexegenia limbata (largest mayfly) which were found in lower abundance in stomachs sampled from other areas. The low relative weight of perch may be partially explained by food quality and quantity.

• Largemouth bass in Pend Oreille River experienced longer length at age than in Thompson and Fernan lakes, and Box Canyon Reservoir (Rieman 1983; Liter 1991). Largemouth bass exceed 400 mm (16 in) by age 6 in Pend Oreille River, Idaho whereas in Thompson and Fernan lakes and Box Canyon Reservoir they do not exceed 400 mm until ages 9, 7 and 8, respectively (Rieman 1983; Liter 1991). Higher growth rates of largemouth bass in the Pend Oreille River are most likely a result of low densities and abundance of forage fishes as growing seasons are similar between the systems. Long Lake, Washington, which has a longer growing season than Pend Oreille River (2,300 degree days vs 1,100 degree days), had longer length at age from ages 1 to 5. However, length at age from age 6 to 10 was similar (Hatch 1991). Once largemouth bass in the Pend Oreille River switched to a piscivorous diet (-100 mm), year to year increases in length were

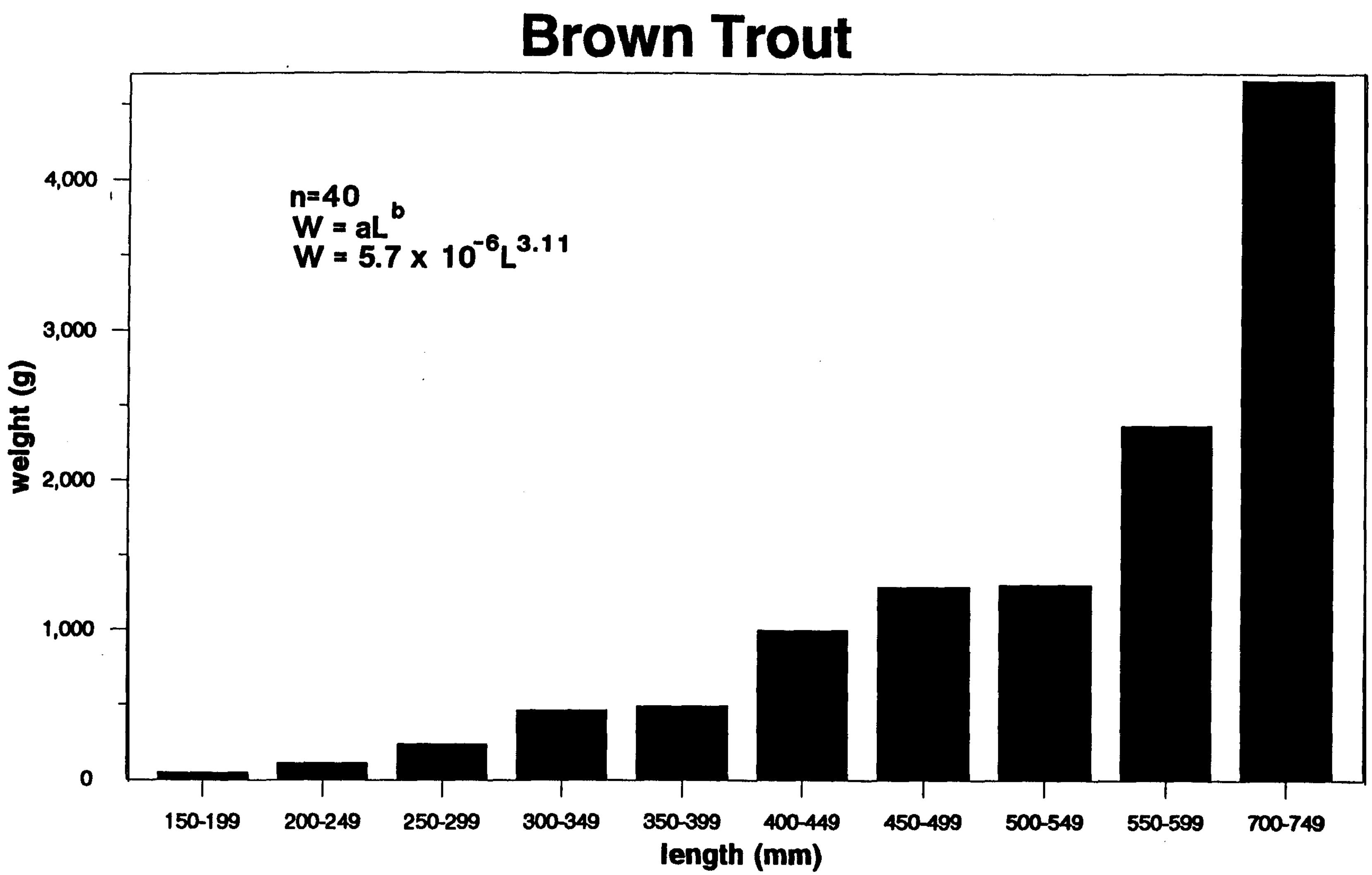


Figure 26. Weight (g) as a function of length (mm) for brown trout from Pend Oreille River, Idaho.

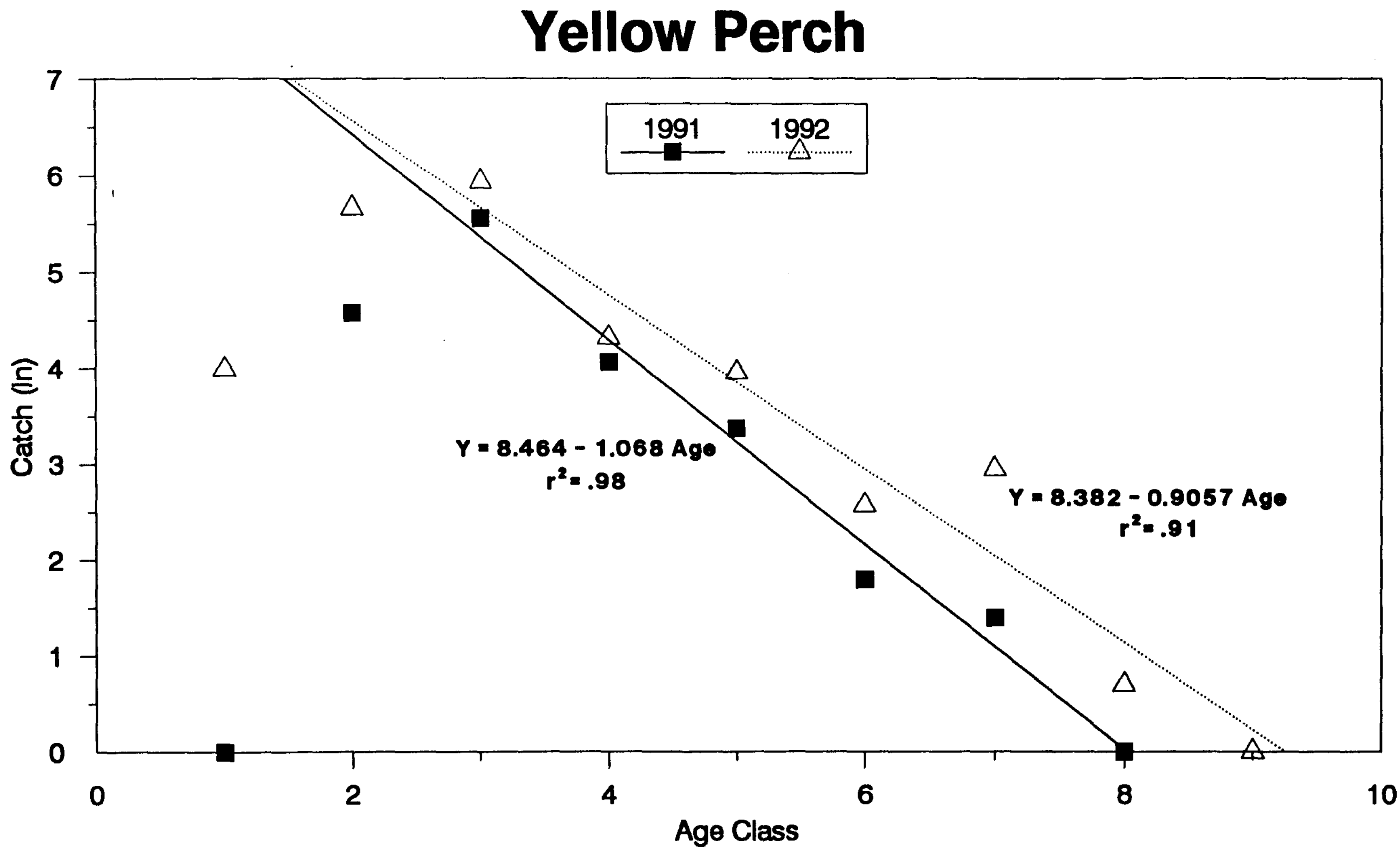


Figure 27. Catch curve to estimate instantaneous total mortality for yellow perch sampled during 1991 and 1992 from the Pend Oreille River, Idaho.

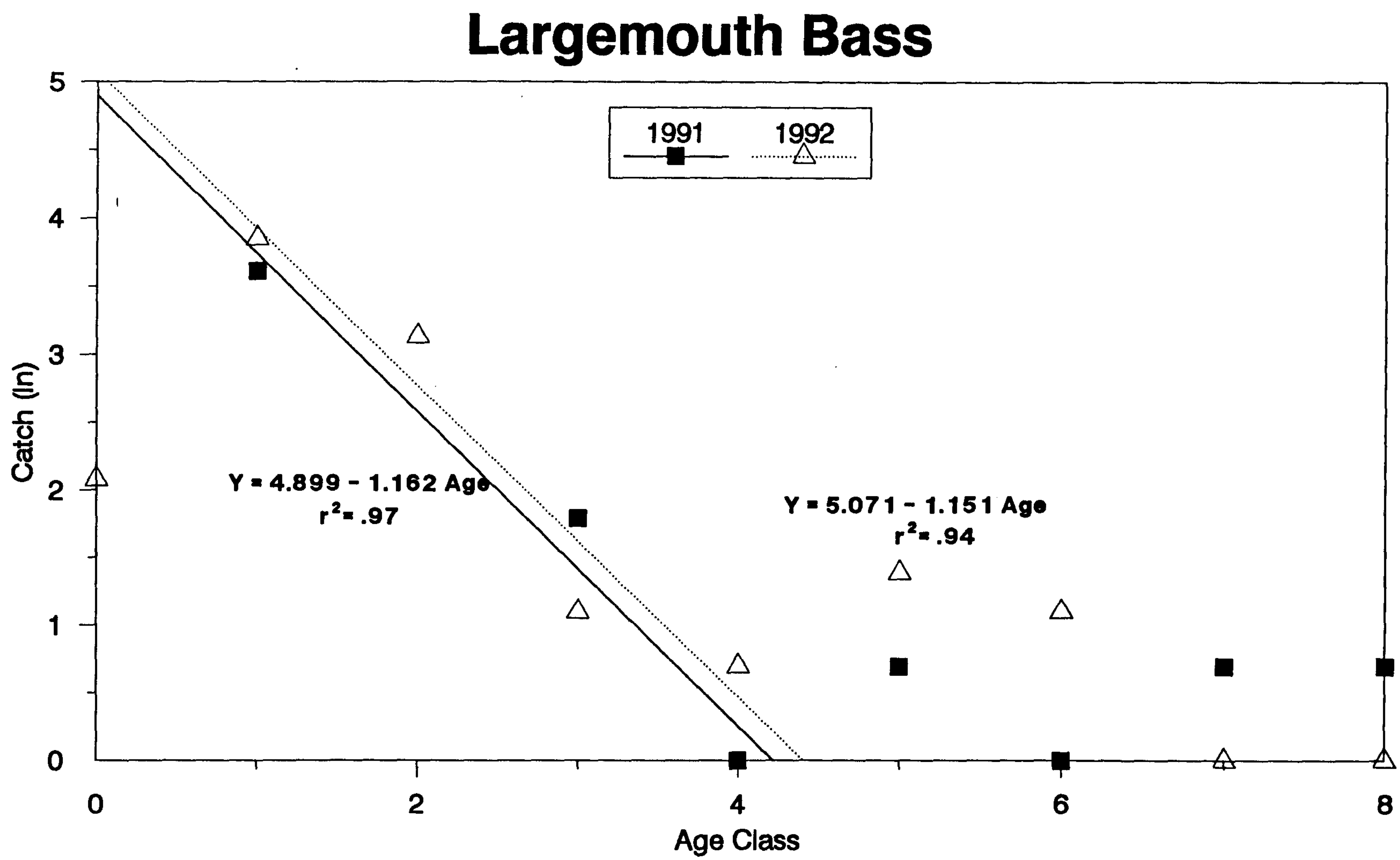


Figure 28. Catch curve to estimate instantaneous total mortality for largemouth bass sampled during 1991 and 1992 from the Pend Oreille River, Idaho.

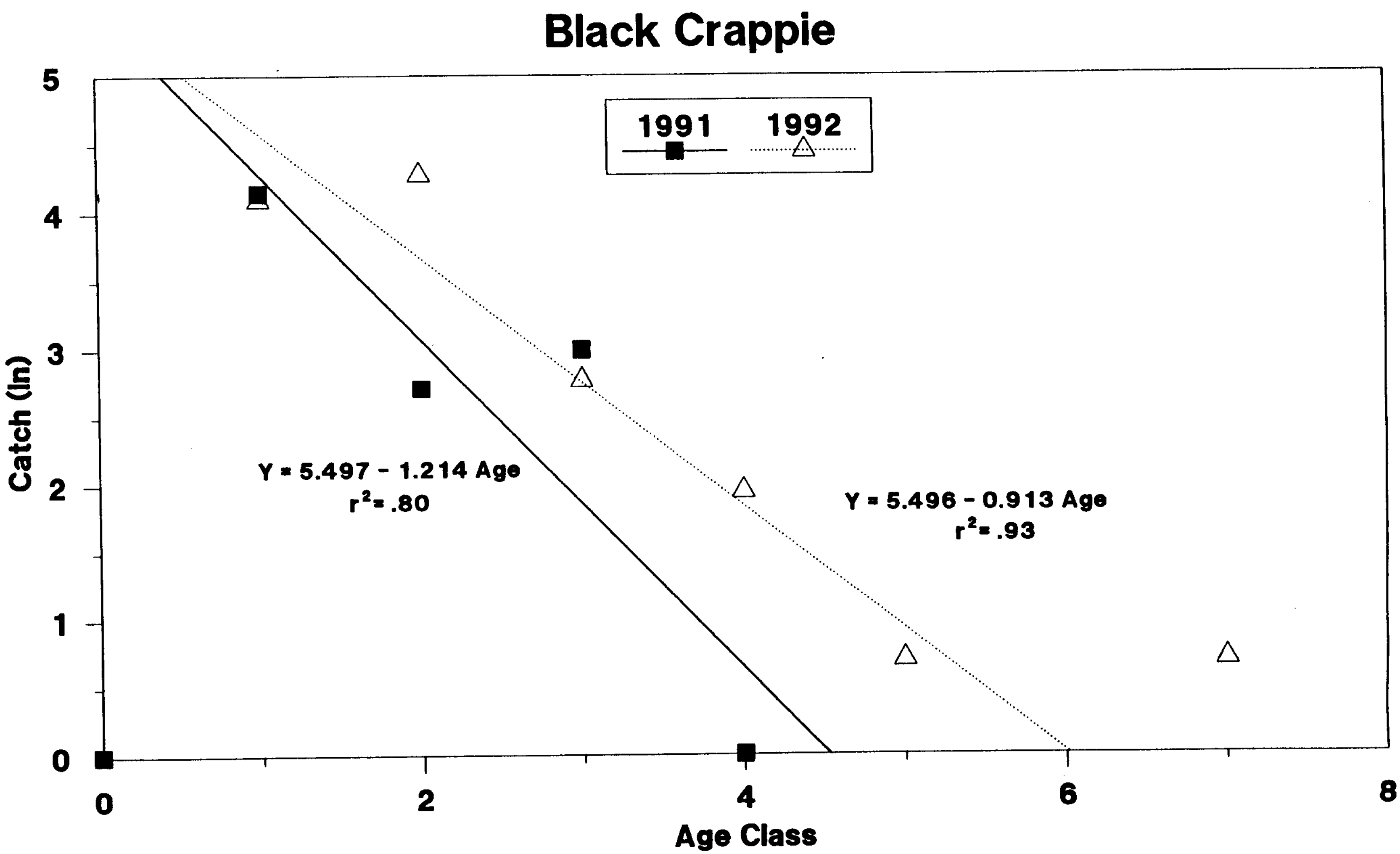


Figure 29. Catch curve to estimate instantaneous total mortality for black crappie sampled during 1991 and 1992 from the Pend Oreille River, Idaho.

larger in the Pend Oreille River than Long Lake. A relative weight of 112% indicates that largemouth bass do have adequate forage.

Growth of black crappie in the Pend Oreille River, Idaho is generally higher than reported for waters located in the west. Length of black crappie at each age class were consistently higher in the Pend Oreille River, Idaho than Box Canyon Reservoir. When average back-calculated lengths at age of black crappie from Pend Oreille River was compared to the average of Montana lakes (Carlander 1977), fish > age 2 were consistently longer in Pend Oreille River. A piscivorous diet after age 1 may explain an increase in growth after age 1 for black crappie in Pend Oreille River. A relative weight of 107% suggests that black crappie have adequate forage in the Pend Oreille River.

Growth of brown trout in the Pend Oreille River is higher than reported for lakes and rivers of North America. Diets of brown trout were composed almost exclusively of fish which possibly explains their high growth rates. Temperatures in the Pend Oreille River were generally suitable for growth of brown trout, as temperatures usually remained between 4 and 21°C (278 out of 365 days) which are required for growth (Stevenson 1987). However, the large average lengths of brown trout from the Pend Oreille River, Idaho (n=2) may have been from fish that migrated to/from Pend Oreille Lake where more optimal year round temperatures and abundant kokanee populations are present.

Mortality

Annual mortality was > 60% for yellow perch, largemouth bass and black crappie during 1991 and 1992. High mortalities may be the result of the winter drawdown, emigration and severe winters as temperatures usually drop to 0°C. Annual mortality was lower during 1992 than in 1991 for all three species which may reflect the mild 1991-1992 winter. Water temperatures during the winter of 1991-1992 were warmer as they did not drop below 2.5°C. Temperatures exceeded 10°C by early April during 1992, whereas during 1991 temperatures did not reach 10°C until late May.

Fishing pressure is almost nonexistent in the Pend Oreille River, Idaho. Fishermen were seldom seen and those who were checked had limited numbers of game fishes. Annual fishing mortality of largemouth bass in Box Canyon Reservoir was estimated at 2.4% (Ashe 1991) which is probably considerably higher than in Pend Oreille River, Idaho. Because of the low fishing mortality, annual mortality of fish in the Pend Oreille River, Idaho can be explained almost exclusively as natural mortality.

Annual mortality of largemouth bass from ages 1 to 4 was 69% during 1991 and 68% during 1992. These high mortality rates are comparable to Long Lake (A = 62%), a system that also experiences winter drawdown (Hatch 1991). Sheehan et al. (1990) and Pitlo (1992) found that largemouth bass need zero velocities and an average depth of 1.2 m (4 ft) for adequate overwinter survival. Drawdown may be forcing largemouth bass from the sloughs as maximum depth usually is around 1 m. Fish that enter the main river channel most likely do not find zero velocities necessary for good overwinter survival, thus they may emigrate from the system. Emigration from the river probably accounts for the bulk of natural mortalities.

Liter (1991) found overwinter survival for age-0 largemouth bass ranging from 0.4 to 3.9% in Box Canyon Reservoir during 1989 and 1990. As Pend Oreille River, Idaho experiences winter drawdowns of 3.5 m (11.5 ft), we might expect overwinter survival of age-0 largemouth bass to be < 1%. No age 2 largemouth bass were sampled during 1991 possibly indicating that severe winters combined with drawdown could limit recruitment to the fishery.

Estimated annual mortality rates of black crappie were comparable to largemouth bass. During 1991 and 1992, annual mortality rates were 70 and 60%. Sheehan et al. (1990) and Pitlo (1992) indicated black crappie had the same overwintering requirements as largemouth bass which probably explains why black crappie annual mortality rates are similar to largemouth bass in the Pend Oreille River.

Objective 5. To determine the effects of drawdown on fish populations in the Pend Oreille River, Idaho.

INTRODUCTION

Comparisons of fish communities were made between the Pend Oreille River, Idaho and the Pend Oreille River, Washington (Box Canyon Reservoir) located immediately downstream of Albeni Falls Dam. The limnology of Box Canyon Reservoir is similar to the Pend Oreille River, Idaho. However, Box Canyon Reservoir is not drawn down every winter so differences in fish community structure between the two areas can generally be explained as an effect of drawdown. Dense aquatic macrophyte communities exist in Box Canyon Reservoir, probably a result of the lack of drawdown that occurs in this system.

METHODS

Comparisons of fish communities were made between Pend Oreille River and Box Canyon Reservoir by gill netting and electrofishing similar habitat types during 1992 (Figure 30). Comparisons were made between fishes sampled in littoral habitats with substrate sizes < 15 mm and from sloughs. Each habitat was divided into 0.5 km sections and were randomly sampled during each stage of drawdown (Table 7). Two sites were sampled in sloughs and along the main river channel from the Pend Oreille River, Idaho, whereas one site was sampled in sloughs and along the main river channel from Box Canyon Reservoir.

Gill nets were set overnight and sampling was repeated for two nights at each station. Sets were perpendicular to shore with the smallest mesh size alternated towards and away from shore. Groups of six nets were fished overnight at each site. Each group was composed of one floating and five sinking experimental gill nets. Two sinking nets were multifilament with five, 14.63 x 1.83 m (48 x 6 ft) panels with mesh size (stretch) ranging from 38.1 (1.5 in) to 139.7 mm (5.5 in). Two other sinking nets were monofilament with five, 9.14 x 1.83 m (30 x 6 ft) panels with mesh size ranging from 38.1 to 139.7 mm. One sinking net was multifilament with seven, 7.62 x 1.83 m (25 x 6 ft) panels with mesh size ranging from 51 (2 in) to 203 mm (8 in). The floating experimental gill nets were multifilament and had five, 14.63 x 1.83 m (48 x 6 ft) panels with mesh size (stretch) ranging from 138.1 to 139.7 mm. The floating gill net was submerged to the bottom in areas of heavy boat traffic.

Nighttime electrofishing consisted of 10 minutes of continuous shocking effort at each littoral sampling station. Electrofishing was conducted by paralleling the shoreline in waters generally < 1.3 m deep with a constant output of approximately 400 volts and 3.5 amps. Electrofishing was repeated at each station for three nights during refill and highpool and for two nights during drawdown and lowpool to minimize night to night variation.

Catch rates were determined for each species at each habitat type for Pend Oreille River, Idaho and Box Canyon Reservoir. Differences in catch rates between the two systems are assumed to be attributed to drawdown. Largemouth bass, black crappie and pumpkinseed were combined into one guild (centrarchids) and catch rates were analyzed during each stage of drawdown.

Geographic Information System (GIS) was used to determine changes in available habitat as a result of drawdown. Specific habitat requirements (velocity, substrate, vegetation and depth) of fishes affected by drawdown were overlaid through G.I.S. to determine the amount of habitat available in the Pend Oreille River during summer and winter months. Habitat availability under a hypothetical 2 m (6.5 ft) drawdown was also evaluated.

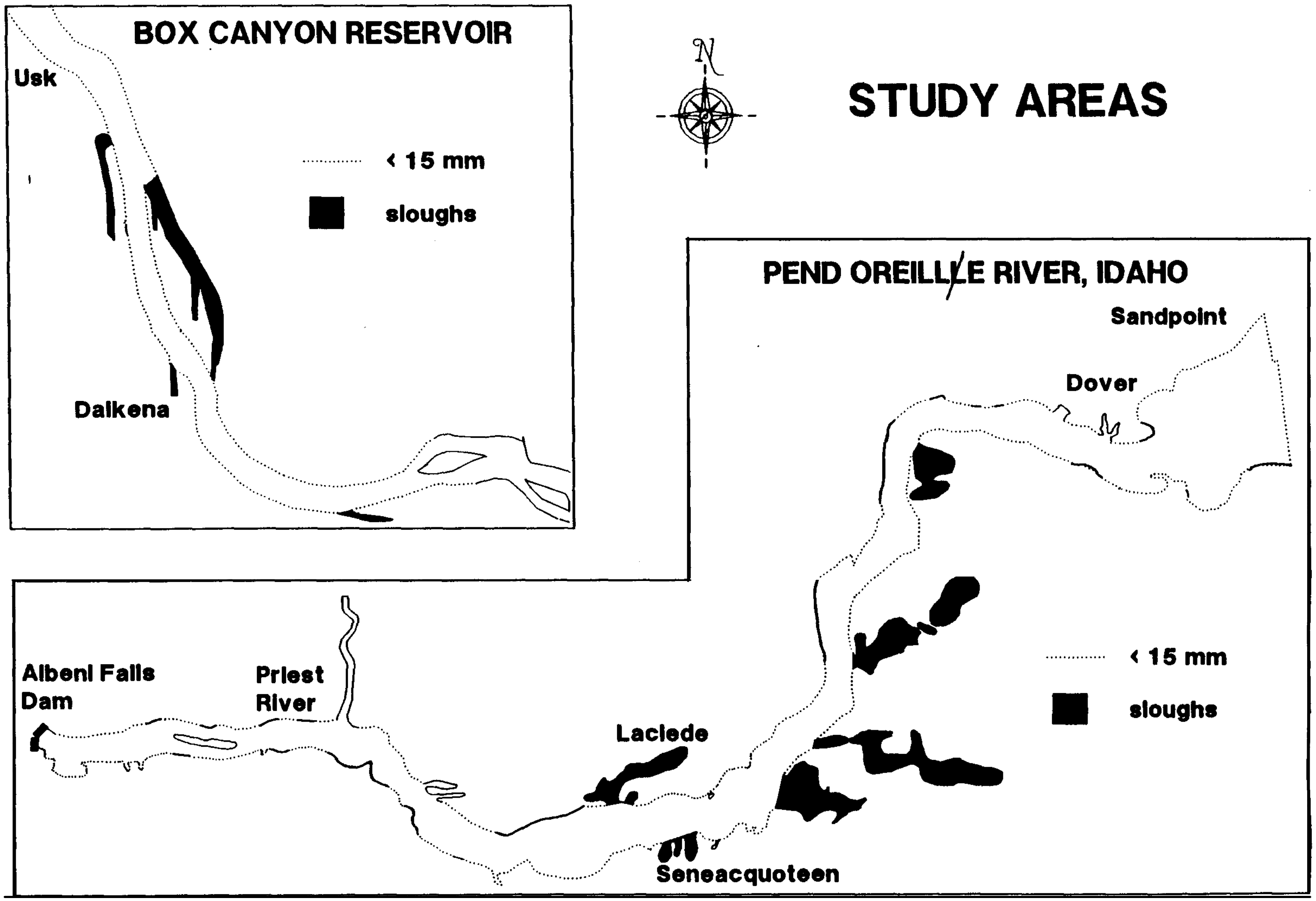


Figure 30. Study areas in Pend Oreille River, Idaho and Box Canyon Reservoir where fishes were sampled. Comparisons of fish communities were made between sloughs and along the main river channel where the average substrate size is < 15 mm.

RESULTS

Comparison of Fish Communities

Over 4,400 net hours of gill netting and 730 minutes of electrofishing were used to compare the fish communities in the Pend Oreille River, Idaho and Box Canyon Reservoir and 15,964 fish were sampled representing 22 species (Table 25). Catch rates of mountain whitefish, peamouth, northern squawfish, redside shiner, largescale sucker, Catostosmus macrocheilus and brown bullhead were higher in Idaho than in Box Canyon Reservoir for both gill netting and electrofishing (Figure 31). However, catch rates of tench Tinca tinca, longnose sucker C. catostomus, pumpkinseed, largemouth bass and black crappie were higher in Box Canyon Reservoir than in Pend Oreille River, Idaho for both gill netting and electrofishing. Collectively, these fishes represented > 98% of the catch. All trout species combined represented < 1% of the catch in both Idaho and Washington. Largemouth bass, black crappie and pumpkinseed are the predominant game fishes that experienced lower catch rates in Pend Oreille River, Idaho than in Box Canyon Reservoir.

During refill, sampling results from electrofishing and gill netting showed higher catch rates of centrarchids in Box Canyon Reservoir than Pend Oreille River, Idaho for both the main river channel and the sloughs (Figure 32). All catch rates were significantly ($P < 0.1$) higher in Box Canyon Reservoir than in Pend Oreille River, Idaho except in comparison of the main river channel. Although comparisons of the main river channel are not significantly different, catch rates in Box Canyon Reservoir were at least 4.5 times higher than any of the catch rates experienced in Pend Oreille River, Idaho.

During highpool, higher catch rates were experienced along the main river channel in Box Canyon Reservoir (Figure 33). Catch rates from sloughs were similar between Pend Oreille River and Box Canyon Reservoir for gill netting and electrofishing. Wide confidence intervals in Box Canyon Reservoir were a result of the difficulty in sampling dense weed beds.

During highpool, most centrarchids sampled were smaller fish (Figure 34). The length frequency distribution of largemouth bass indicate 96% of the fish sampled from the Pend Oreille River, Idaho were < 210 mm (age-0 and 1), whereas 77% from Box Canyon Reservoir were < 210 mm.

During drawdown, average catch rates of centrarchids were higher in Box Canyon Reservoir than in Pend Oreille River, Idaho (Figure 35). Catch rates in Box Canyon Reservoir during drawdown were highly variable and confidence intervals show no statistical differences ($P > 0.10$).

During lowpool, few centrarchids were sampled in Pend Oreille River, Idaho which resulted in the lowest catch rates of the year (Figure 36). Average catch rates sampled by gill netting were higher in Box Canyon Reservoir in all areas except the main river channel. No statistical differences were found. Average catch rates by gill netting along the main river channel during lowpool were higher in Pend Oreille River, Idaho than in Box Canyon Reservoir. Gill netting catch rates were 26 times higher in sloughs than along the main river channel during lowpool for Box Canyon Reservoir. Gill netting catch rates were higher along the main river channel than the sloughs for Pend Oreille River, Idaho (Figure 36).

Table 25. Number of fishes sampled by gill netting and electrofishing on Pend Oreille River, Idaho (Idaho) and Box Canyon Reservoir, Washington (BCR) during 1992.

	Main River Channel substrate < 15 mm		Sloughs		Total		Overall Composition	%
Species	Idaho	BCR					Idaho	
kokanee salmon							0.0	0.0
cutthroat trout							0.2	0.0
cutthroat (hatchery)							0.0	0.0
rainbow trout							0.1	0.1
rainbow (hatchery)							< 0.1	0.0
brown trout							0.2	0.2
brook trout							< 0.1	0.0
bull trout							< 0.1	0.0
lake trout							< 0.1	0.0
lake whitefish							0.4	0.0
mountain whitefish							3.9	0.6
peamouth							12.0	2.2
northern squawfish							10.9	4.4
redside shiner							2.7	0.0
tench							8.4	23.8
longnose sucker							2.4	3.4
largescale sucker							3.6	1.6
brown bullhead							8.1	2.6
pumpkinseed							10.3	19.9
largemouth bass							5.1	9.8
black crappie							2.0	5.8
yellow perch							29.7	25.6
slimy sculpin							< 0.1	0.0
TOTAL								100

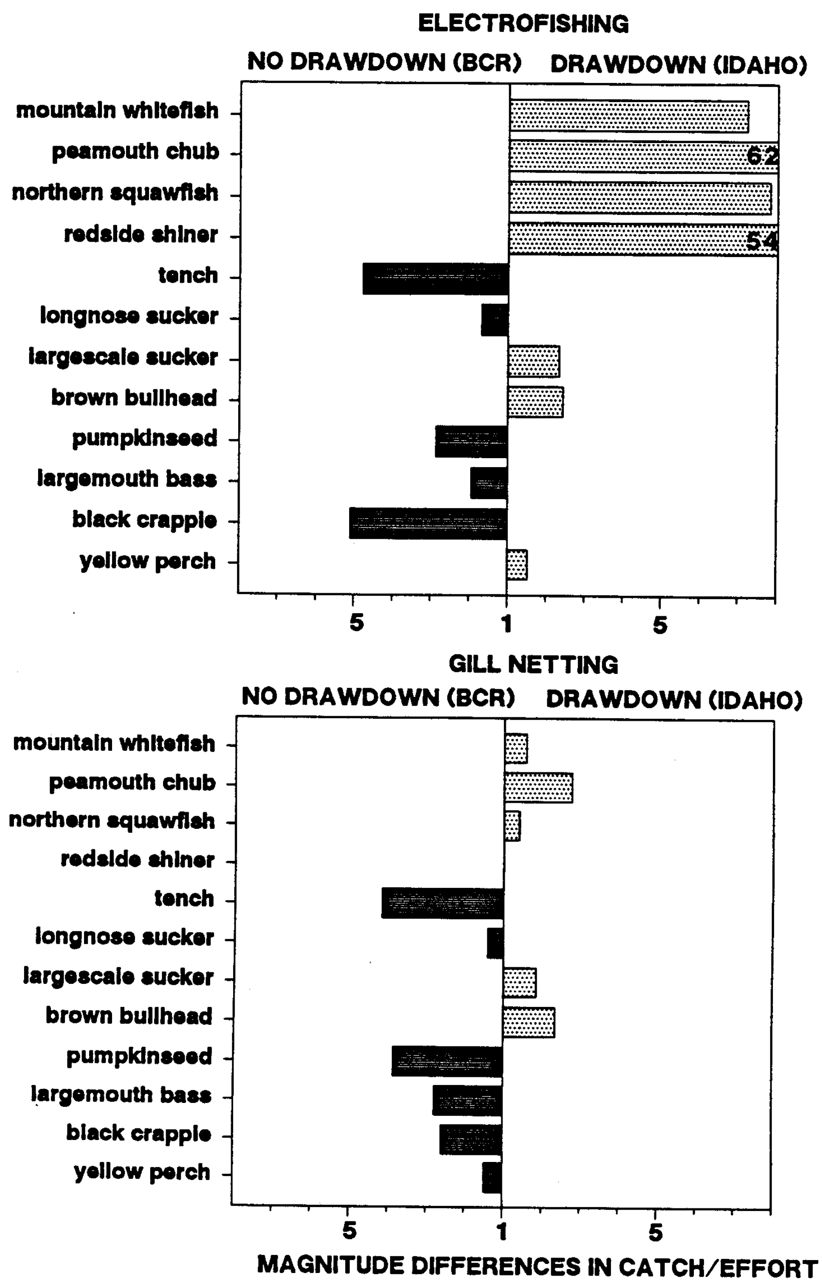


Figure 31. The magnitude of difference in catch rates of fishes sampled between Box Canyon Reservoir (BCR) and the Pend Oreille River, Idaho (Idaho)

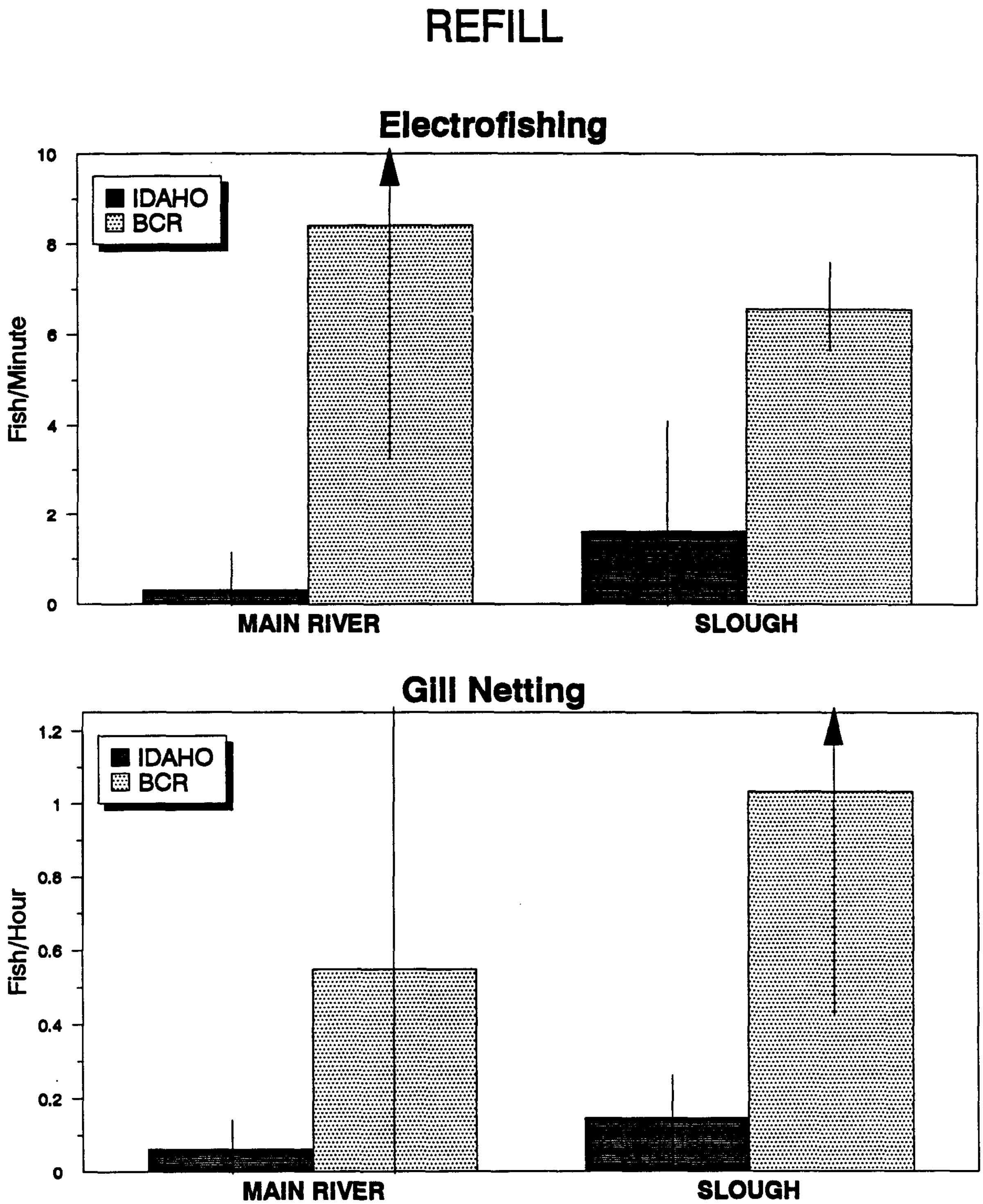


Figure 32. Comparison of electrofishing and gill netting catch rates from centrarchids (largemouth bass, black crappie and pumpkinseed) sampled along the main river channel (average substrate size < 15 mm) and sloughs from Pend Oreille River, Idaho (Idaho) and Box Canyon Reservoir (BCR) during refill 1992. Vertical bars indicate 90% confidence intervals.

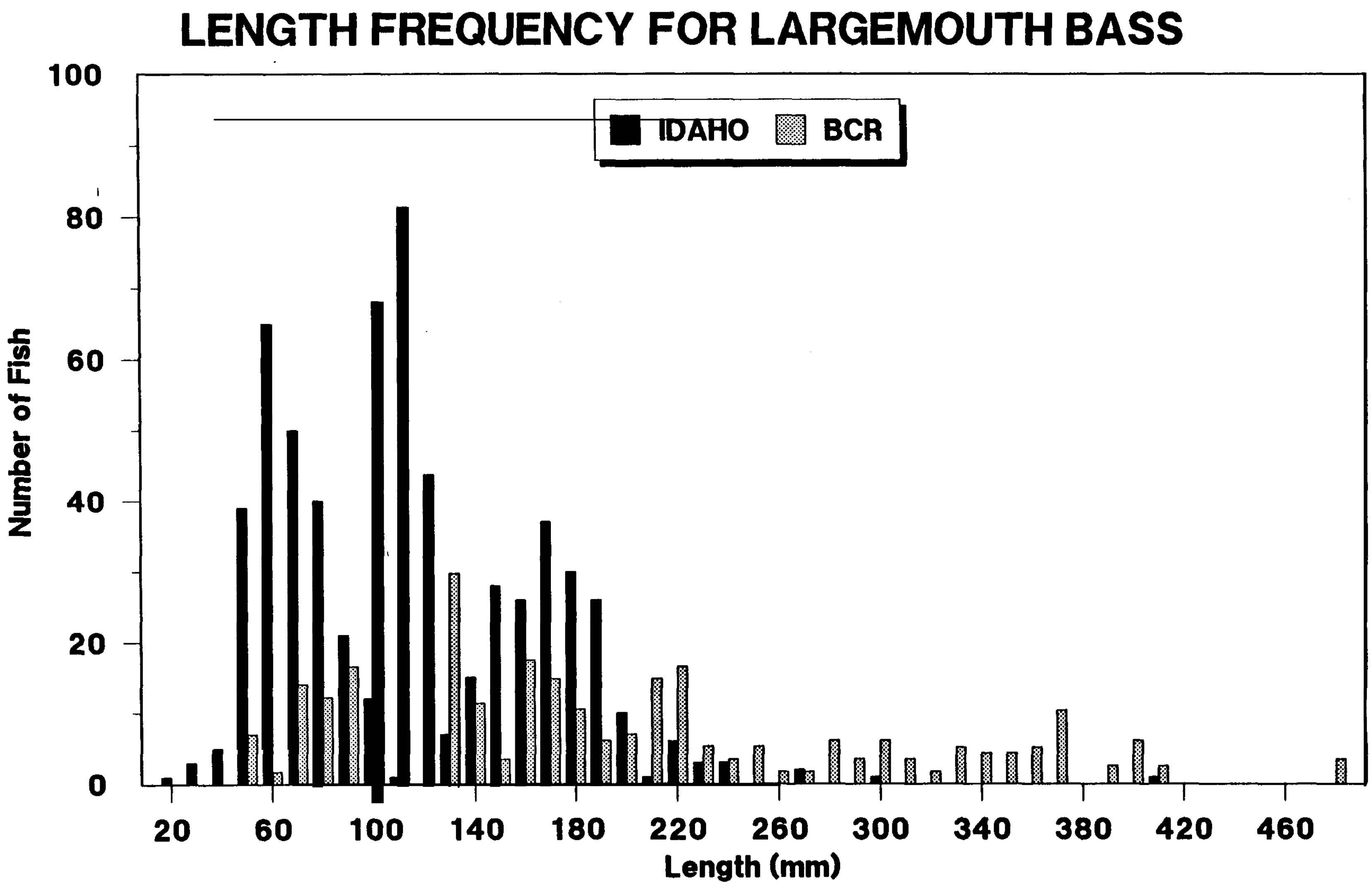


Figure 34. Length (mm) frequency diagram of largemouth bass sampled during July and August of 1992 from Pend Oreille River, Idaho (Idaho) and Box Canyon Reservoir (BCR).

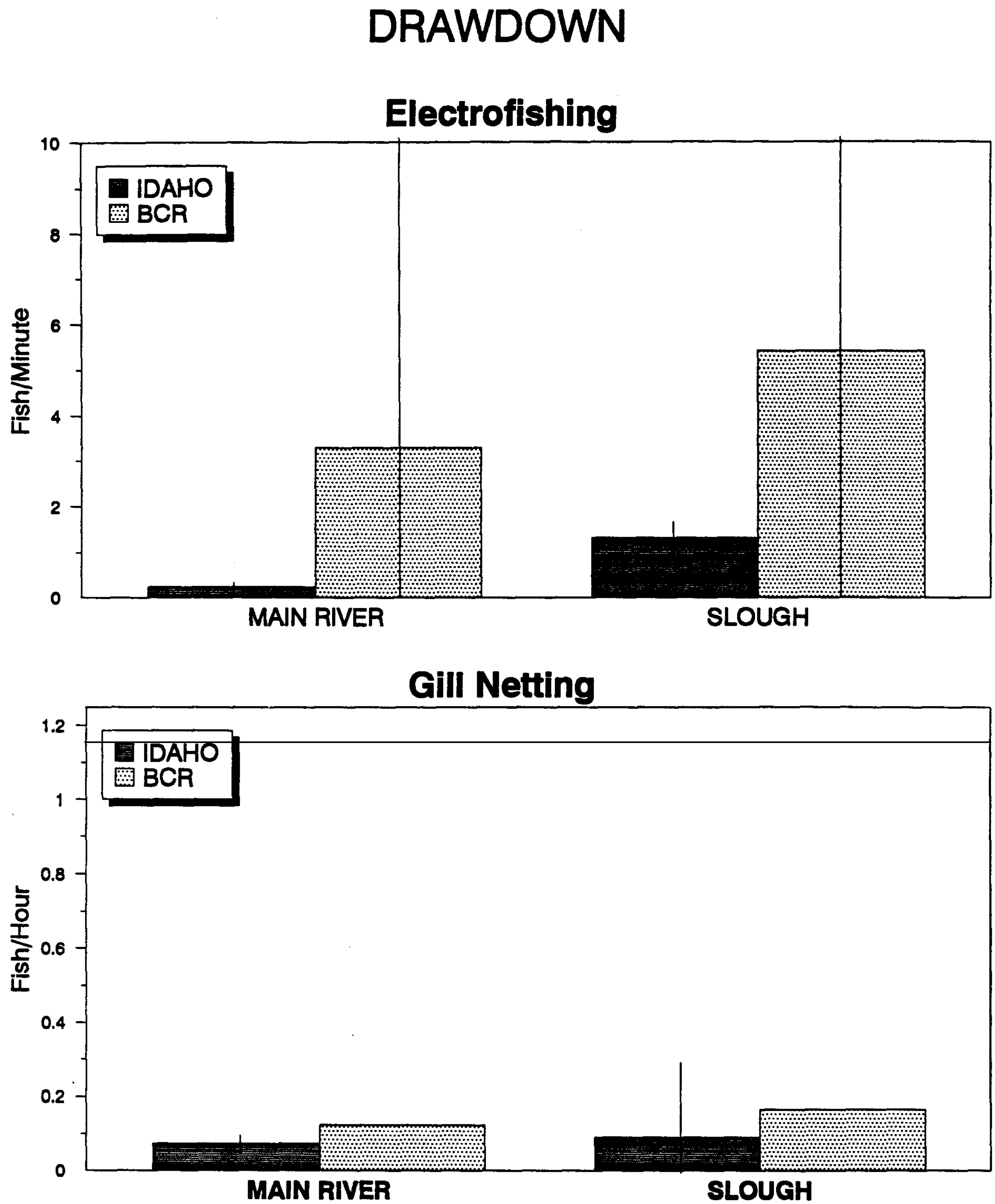


Figure 35. Comparison of electrofishing and gill netting catch rates from centrarchids (largemouth bass, black crappie and pumpkinseed) sampled along the main river channel (average substrate size < 15 mm) and sloughs from Pend Oreille River, Idaho (Idaho) and Box Canyon Reservoir (BCR) during drawdown 1992. Vertical bars indicate 90% confidence intervals.

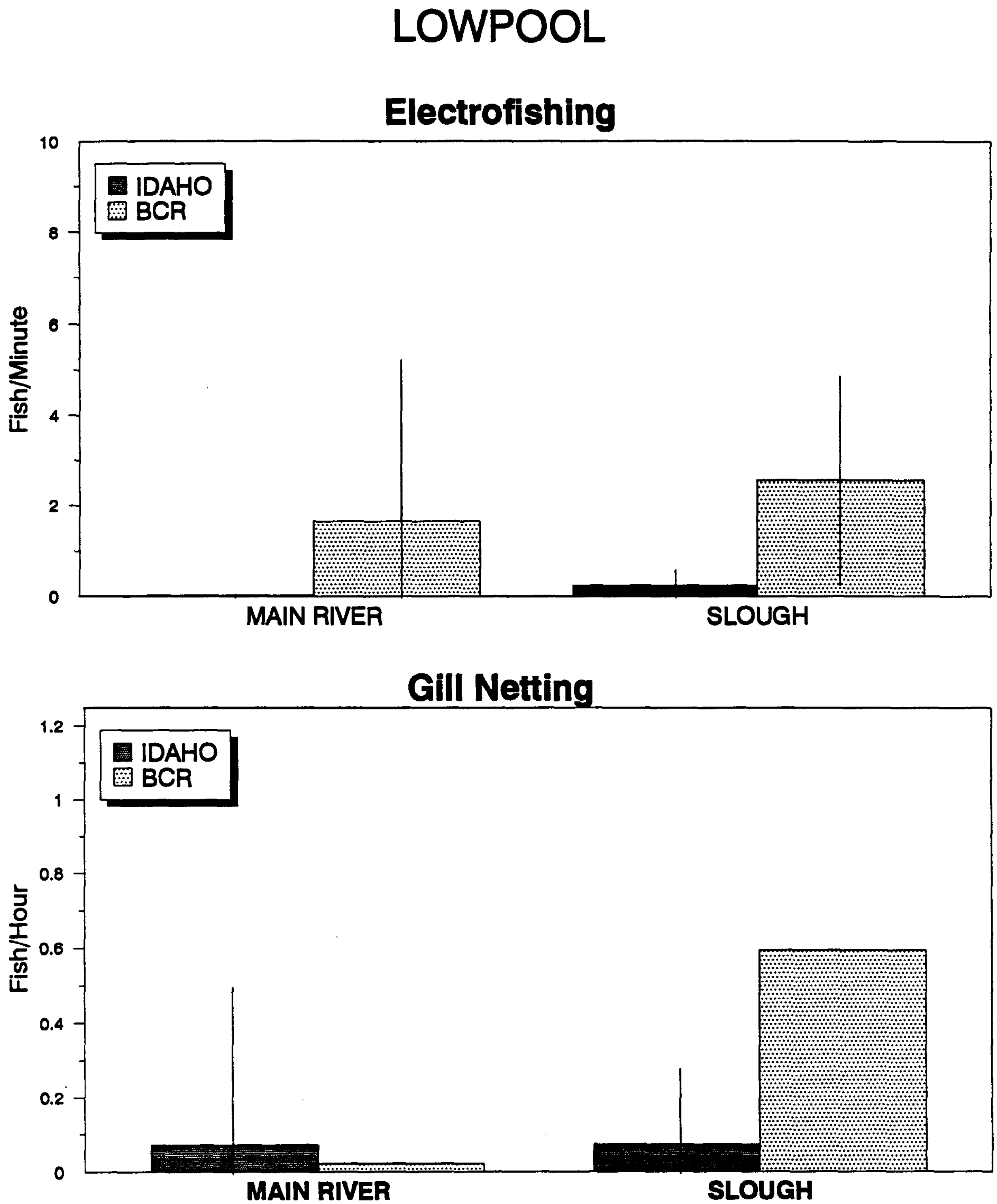


Figure 36. Comparison of electrofishing and gill netting catch rates from centrarchids (largemouth bass, black crappie and pumpkinseed) sampled along the main river channel (average substrate size < 15 mm) and sloughs from Pend Oreille River, Idaho (Idaho) and Box Canyon Reservoir (BCR) during lowpool 1992. Vertical bars indicate 90% confidence intervals.

Habitat Availability

Suitable summer habitat for largemouth bass include vegetation, wood structures and open water bordering the structures with velocities < 6 cm/s (Ashe and Scholz 1992; Pitlo 1992). Our analysis of habitat conditions indicate about 1,000 ha is available of suitable summer largemouth bass habitat in the Pend Oreille River, Idaho which is approximately 25% of the total surface area (Figure 37).

During winter, Pend Oreille River, Idaho is drawn down 3.5 m which decreases the total area of the river generally from 3,900 ha to about 3,150 ha. Approximately 750 ha (19%) of the river bottom is exposed during drawdown; most dewatered areas are sloughs and shallow bays (Figure 38).

Winter habitat requirements for largemouth bass and similar centrarchids (black crappie and pumpkinseed) include zero velocities and depths > 1.2 m (Sheehan et al. 1990; Ashe and Scholz 1992; Carlson 1992; Pitlo 1992). About 45 ha of suitable winter largemouth bass habitat exist in the Pend Oreille River, Idaho under present drawdown levels (lake elevation 2,051.5 m) which is about 4% of the suitable summer habitat (Figure 39).

If the annual drawdown were limited to 2.0 m, approximately 520 ha would be exposed increasing the surface area of the river by about 230 ha (31% gain) over the surface area of the 3.5 m drawdown. If the 2.0 m drawdown were implemented, the amount of suitable winter habitat for largemouth bass would increase to 325 ha, 7.5 fold over the current winter habitat (Figure 40).

DISCUSSION

Lower catch rates of tench, longnose sucker, pumpkinseed, largemouth bass and black crappie were found in Pend Oreille River, Idaho than Box Canyon Reservoir, Washington. We interpret the lower catch rates as the effects of drawdown on these fishes.

Largemouth bass, black crappie and pumpkinseed were consistently sampled at lower catch rates from Pend Oreille River, Idaho than Box Canyon Reservoir in all stages of drawdown, except from sloughs during highpool and along the main river channel during lowpool. Higher catch rates sampled from sloughs in Pend Oreille River, Idaho during highpool were a result of large numbers of age-0 and 1 fish. High numbers of age 1 fish in Pend Oreille River, Idaho may have resulted from the mild 1991-1992 winter. Large numbers of age-0 fish indicate spawning success is high on the Pend Oreille River, Idaho. During spawning, the Pend Oreille River is usually at fullpool and experiences minimal water-level fluctuations. These conditions are considered favorable for successful spawning of largemouth bass (Mitchell 1982). However, year-class strength in northern waters is generally based on over-winter survival of age-0 fish (Bowles 1985; Rieman 1987).

During winter, higher gill netting catch rates of centrarchids were experienced along the main river channel than in sloughs of the Pend Oreille River, Idaho. However, gill netting catch rates were 26 times greater in the sloughs in Box Canyon Reservoir than along the main river channel. These data indicate that drawdown, which decreases slough depths to < 1 m Pend Oreille River, Idaho, forces centrarchids from the sloughs into the main river. In Box Canyon Reservoir, slough depths often exceed > 2 m which are more suitable for centrarchids (> 1.5 m) and may explain why they were sampled at substantially higher catch rates. Sloughs > 1.5 m in depth have favorable conditions for centrarchids during winter as temperatures are generally 2-4°C warmer than the main river, and dissolved oxygen levels are usually adequate for survival (> 2

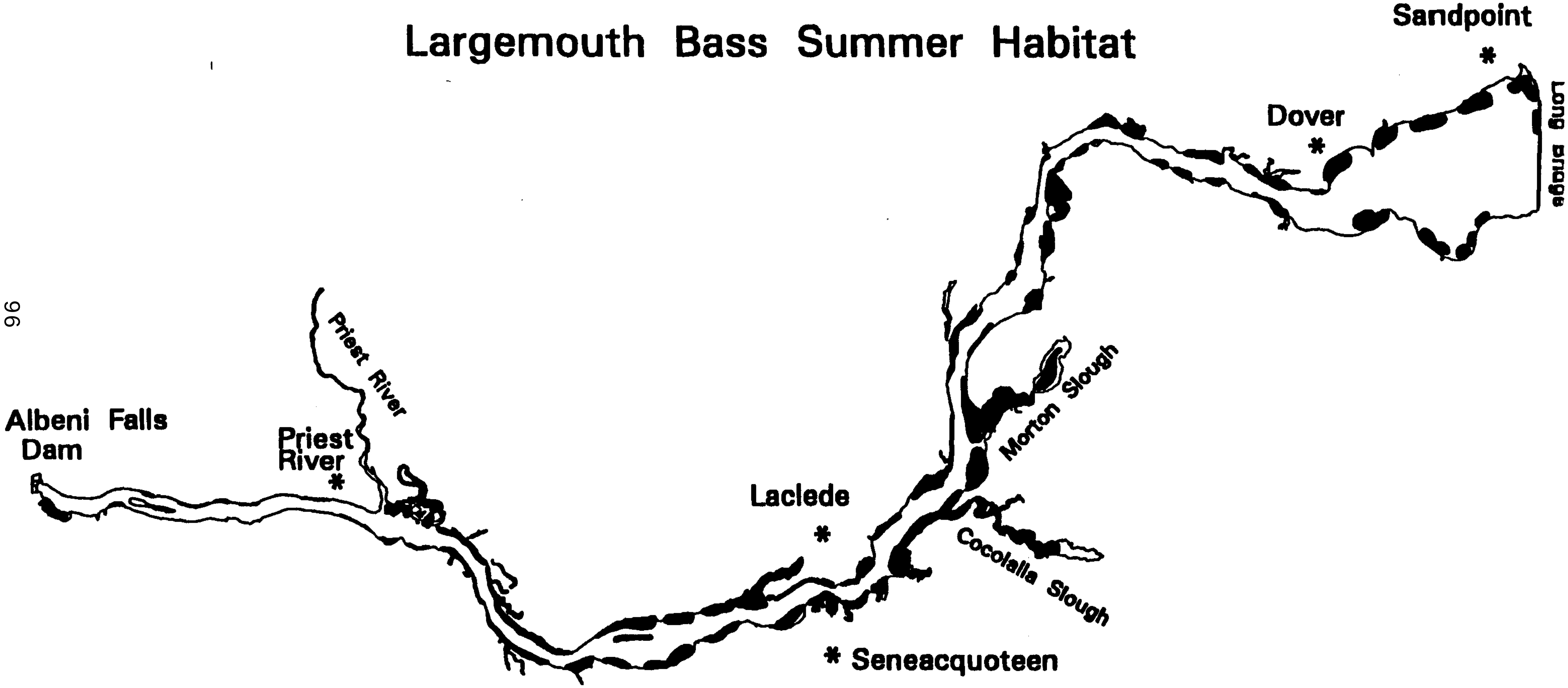


Figure 37. Suitable largemouth bass habitat during highpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

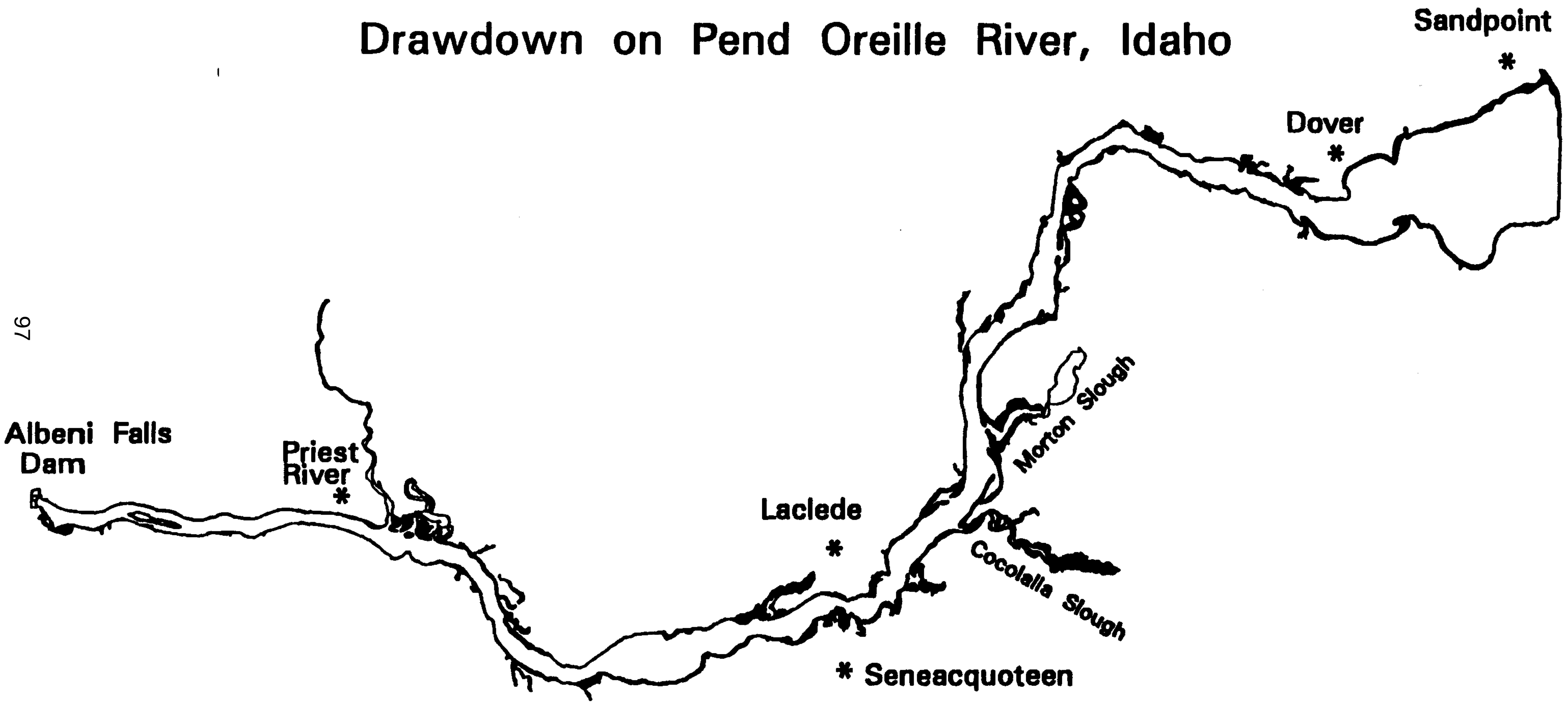


Figure 38. Pend Oreille River, Idaho during a 3.5 m drawdown (lake elevation 2051). Black shading represents areas that are dewatered during drawdown.

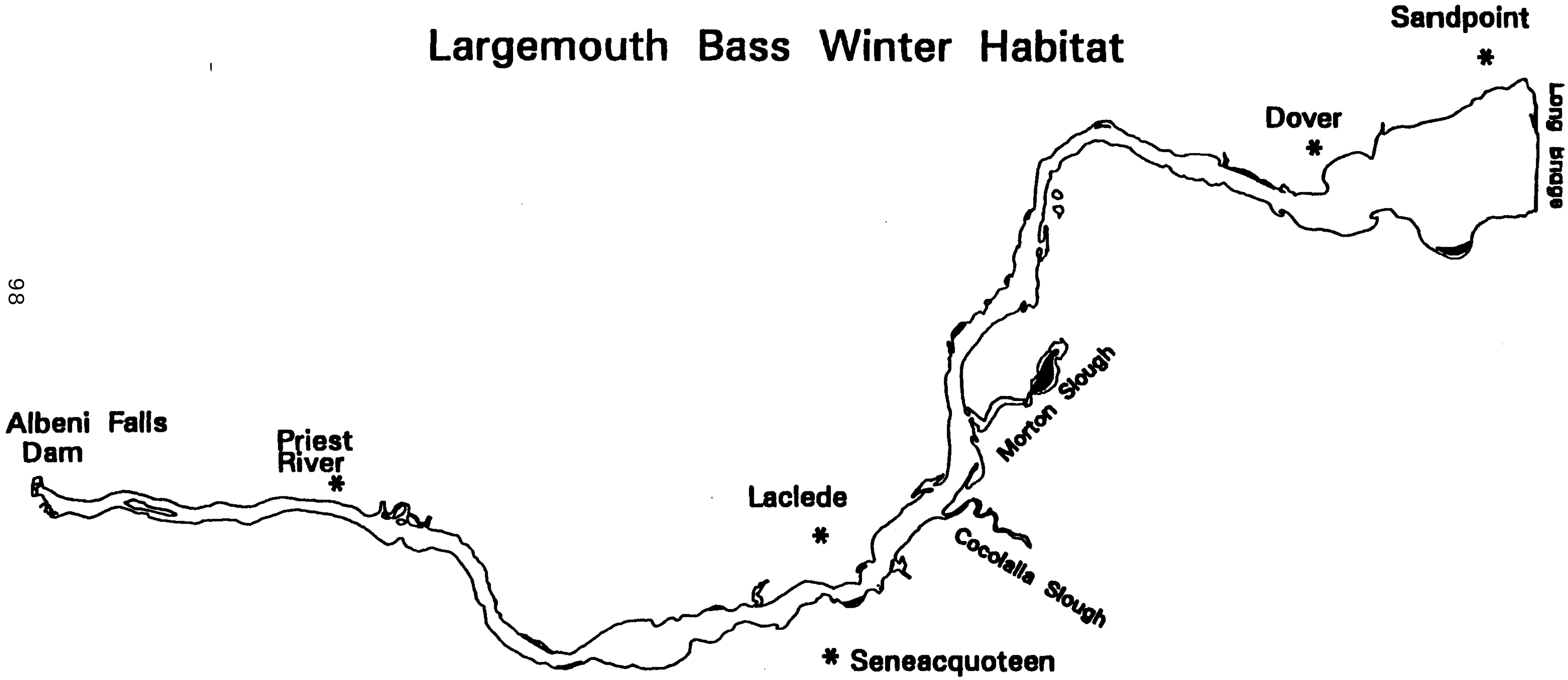


Figure 39. Suitable largemouth bass habitat during lowpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

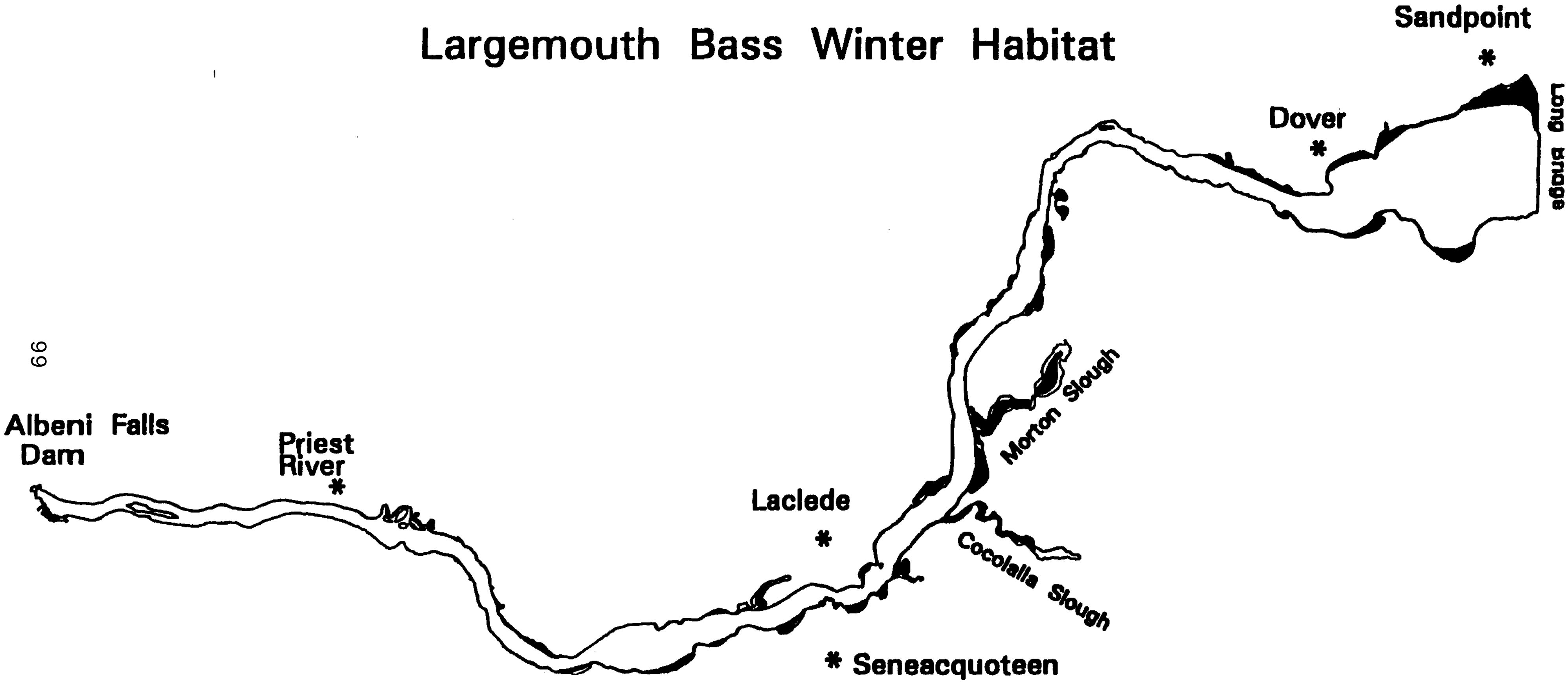


Figure 40. Suitable largemouth bass habitat on Pend Oreille River, Idaho if drawdown was limite to 2 m (lake elevation 2056). Black shading represents suitable habitat.

ppm) (Sheehan 1990; Pitlo 1992). Temperatures in the main river channel of Pend Oreille River often drop to 0°C during winter for extended periods of time. Under controlled conditions, Sheehan et al. (1990) found that when temperatures dropped to 0°C age-0 centrarchids often experienced mortalities of 50%. Pitlo (1992) found that shallow (average depth < 1.2 m) backwater areas often experienced low dissolved oxygen concentrations that resulted in extensive winter kills of centrarchids. Zero velocities found in the sloughs are also important as centrarchids exposed to temperatures < 2°C show little ability to negotiate current (Sheehan et al. 1990). Thus centrarchids forced into the main river channel must find suitable habitat for survival. Low quantities of suitable overwintering habitat probably contribute to the low annual survival rates of centrarchids in the Pend Oreille River, Idaho (Objective 4).

Habitat analysis of Pend Oreille River, Idaho indicates adequate summer habitat is available to support substantial largemouth bass and black crappie populations. Large numbers of age-0 fish sampled during 1991 and 1992 indicate spawning success is high. However, based on our overwintering calculations, overwintering habitat is limited to about 45 ha or 4% of the amount of suitable summer habitat. Typically, backwater areas or sloughs provide the habitat requirements needed for overwintering centrarchids (Sheehan et al. 1990; Carlson 1992; Pitlo 1992). Drawdown in Pend Oreille River, Idaho decreases average slough depths to < 1 m which is unfavorable for overwintering centrarchids (Sheehan et al. 1990; Pitlo 1992). If drawdown in Pend Oreille River were limited to 2 m, a 7.5 fold increase in the amount of overwintering habitat would result and presumably translate into an increase in the sports fishery.

Objective 6. ***To* evaluate *potential introduction of fishes into the Pend Oreille River, Idaho.***

METHODS

Introductions of smallmouth bass Micropterus dolomieui, northern pike Esox lucius, white sturgeon Acipenser transmontanus, channel catfish Ictalurus punctatus and walleye Stizostedion vitreum vitreum to the Pend Oreille River, Idaho were evaluated for potential success. Habitat requirements for each species were determined from literature and compared to the habitat available in the Pend Oreille River. Specific habitat requirements (velocity, substrate, vegetation and depth) of fishes were overlaid through G.I.S. to determine the amount of suitable habitat for each species in the Pend Oreille River. Availability of food abundance and preferred water temperatures were also compared between the Pend Oreille River, Idaho and species requirements. High abundance of suitable habitat attributes may indicate potential success of introductions.

RESULTS

Smallmouth Bass

The literature states that smallmouth bass prefer cool waters with rock and gravel substrates (Scott and Crossman 1973; Coble 1975; Simpson and Wallace 1982). Todd (1987) and Munther (1970) found smallmouth bass to show strong preference for cobble, bolder and other structures during summer, such as log jams. Velocities < 20 cm/s are preferred by smallmouth bass (Todd 1987). Fish typically inhabit waters < 12 m in depth with a preference for depths of 1 to 10 m (Coble 1975; Todd 1987). When temperatures are < 10°C smallmouth bass begin moving to deeper water and seek shelter in crevices, between rocks, holes, submarine caves and hollow logs (Munther 1970; Scott and Crossman 1973; Coble 1975). Munther (1970) found that smallmouth bass in the middle Snake River moved to depths > 2 m when temperatures were < 10°C. Shelter is important for overwintering to prevent downstream displacement of inactive fish (Munther 1970; Scott and Crossman 1973; Coble 1975). Sand, gravel or cobble on gentle slopes is considered good spawning habitat for smallmouth bass with spawning generally occurring at temperatures ranging from 16 to 18°C (Scott and Crossman 1973; Coble 1975; Bratovitch 1985; Todd 1987).

Cobble and boulder substrates represent 2.9% (111 ha) of the surface area of the Pend Oreille River. Of this 111 ha, 90 ha (2.3%) are found in depths < 10 m with velocities < 20 cm/s (Figure 41). Rocky areas > 2 m deep are good overwintering habitats where smallmouth bass can seek shelter to avoid current. Suitable overwintering habitat is reduced by drawdown and represents 20 ha, or 0.6% of the total surface area during lowpool (Figure 42).

Good spawning habitat for smallmouth bass consisting of sand and cobble occurs after the Pend Oreille River reaches highpool, as optimum spawning temperatures (17°C) generally occur during mid-June. Approximately 42 km of shoreline (26%) would be suitable for spawning of smallmouth bass in the Pend Oreille River, Idaho (Figure 43).

Smallmouth bass begin feeding on zooplankton and as they grow, they switch to insects and crayfish and fish. Average zooplankton densities in Pend Oreille River, Idaho are 40 organisms/L which is considered high for northern Idaho. Average zooplankton lengths > 8 mm indicate zooplankton populations currently are not excessively grazed. Crayfish, an important prey item for smallmouth bass,

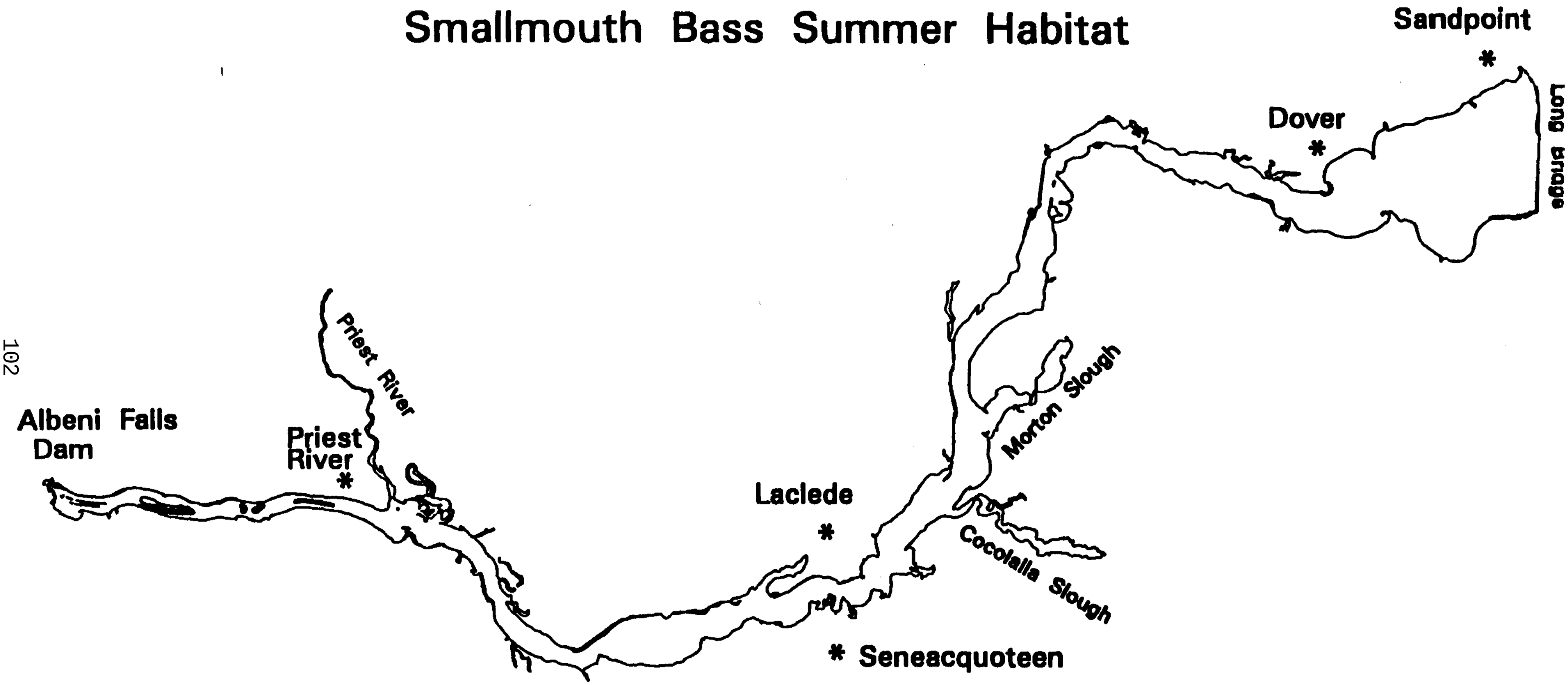


Figure 41. Suitable smallmouth bass habitat on Pend Oreille River, Idaho when temperatures are > 10 C. Black shading represents suitable habitat.

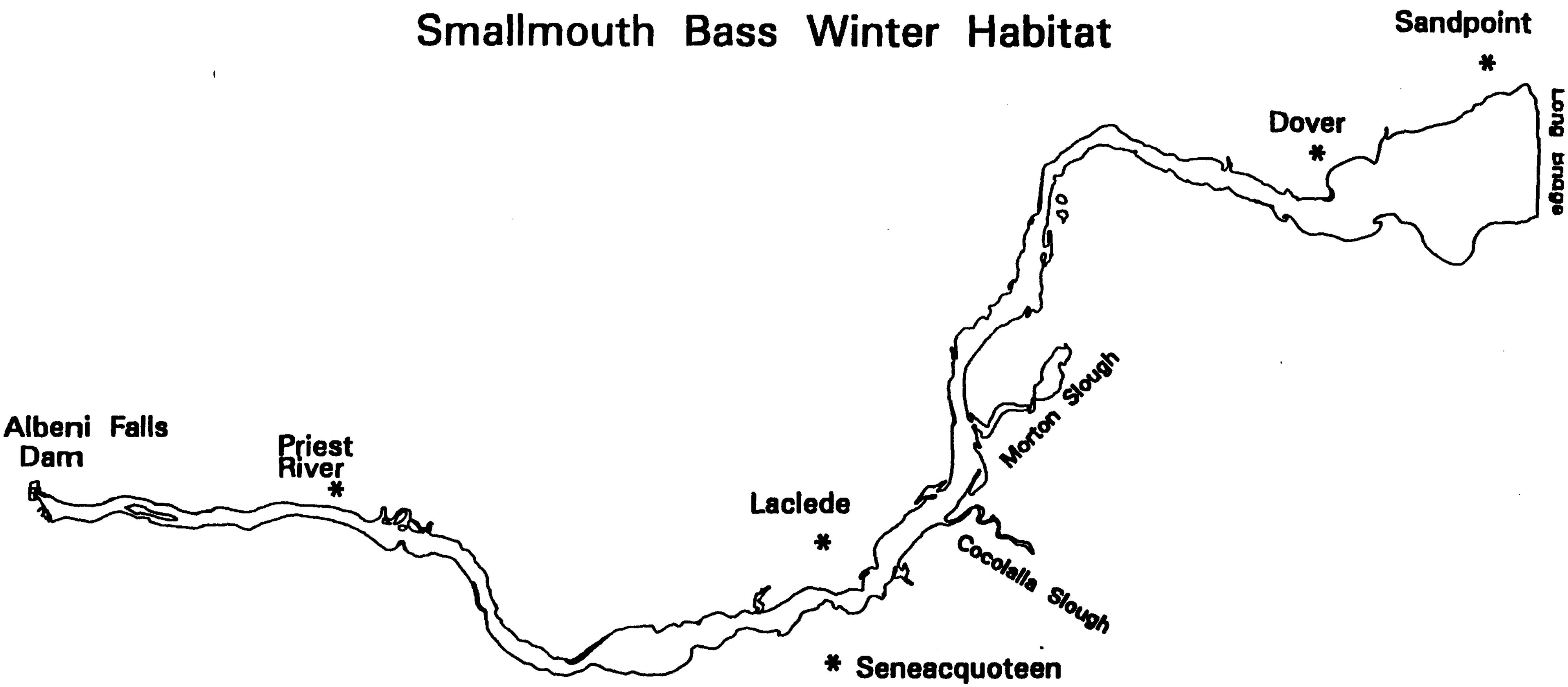


Figure 42. Suitable smallmouth bass habitat on Pend Oreille River, Idaho when temperatures are < 10 C. Black shading represents suitable habitat.

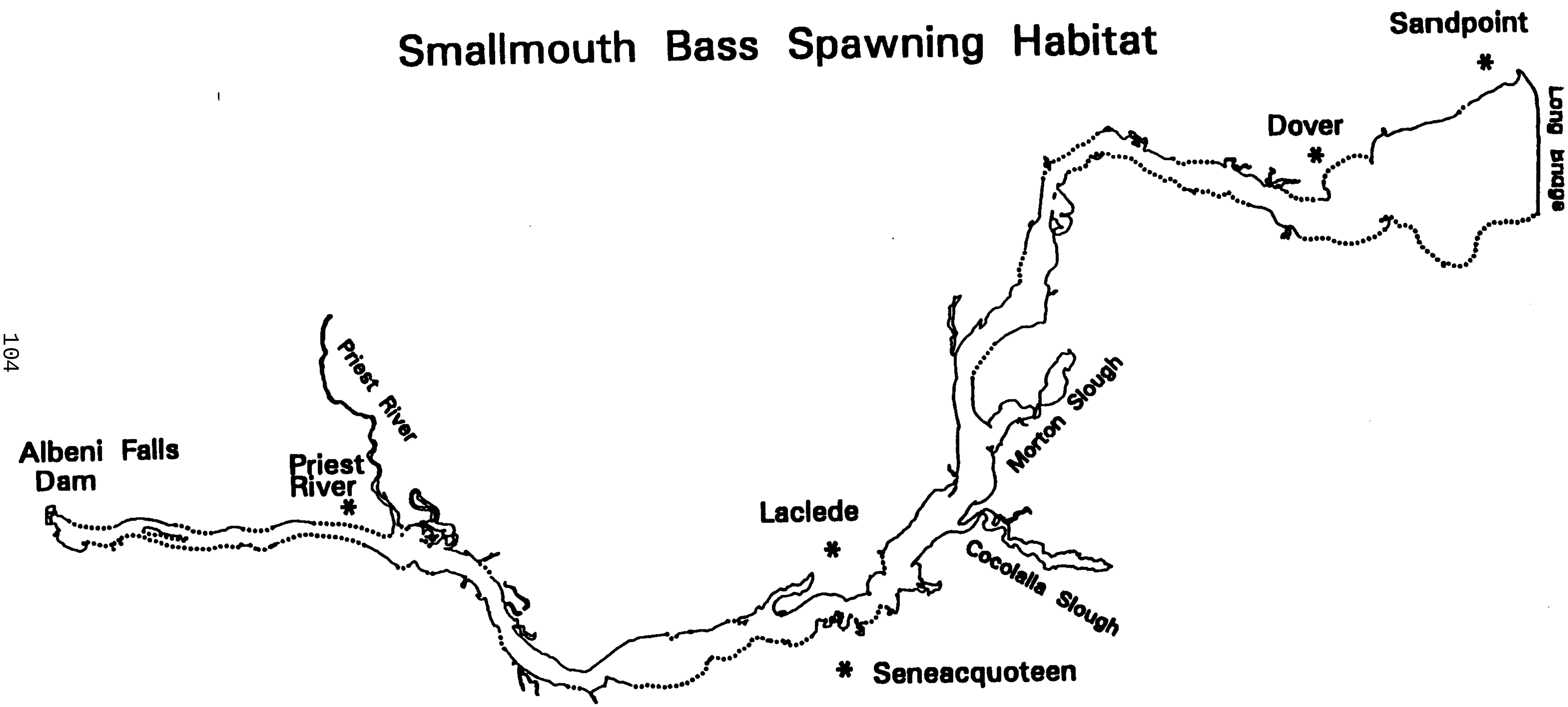


Figure 43. Shoreline spawning habitat available for smallmouth bass on Pend Oreille River, Idaho. Dotted shoreline represents good spawning habitat.

were found in northern squawfish stomachs but none were sampled. Cyprinids are important forage fishes (Scott and Crossman 1973; Coble 1975). Prey fishes are abundant in the system and northern squawfish is the only major predator.

Northern Pike

Northern pike prefer vegetated areas with depths generally < 5m (Carlander 1969; Rich 1992), although others have found them inhabiting waters 30 m deep (Scott and Crossman 1973). Northern pike tend to avoid areas of current (Harrison and Hadley 1978). Growth of northern pike occurs from 2 to 28°C with optimum growth at 19°C (Carlander 1969; Casselman 1978). During winter, pike activity decreases, although they continue to feed and are often found in waters 5 m deep (Scott and Crossman 1973). In deeper systems, northern pike often move to depths > 10 m (Gay and Richards 1989). Data on winter habitat characteristics of northern pike are vague and limited. Northern pike spawn at temperatures ranging from 4.4 to 11.1°C with an average spawning temperature of 9°C (Scott and Crossman 1973). Spawning generally occurs in shallow (< 1 m) vegetated areas with preference for flooded grasses (Scott and Crossman 1973; Groen and Schroeder 1978; Nelson 1978).

Vegetated areas of low velocity (< 3 cm/s) typify good northern pike summer habitat; about 9% (350 ha) of the Pend Oreille River, Idaho (Figure 44). Winter habitat is similar, covering 346 ha of Pend Oreille River (Figure 45). Spawning of northern pike in the Pend Oreille River would probably occur during late April to early May when water temperatures are about 9°C. During this time, water levels have risen approximately 1.7 m from lowpool, inundating habitat devoid of vegetation. As good spawning habitat is considered to be vegetated waters < 1 m, none would be available in the Pend Oreille River.

White Sturgeon

White sturgeon are found in large systems of the western coast of North America (Scott and Crossman 1973). White sturgeon inhabit waters with velocities ranging from 3 to 70 cm/s (Apperson and Anders 1990; Bennett et al. 1993). Coon et al. (1977) and Lukens (1985) noted that sturgeon tended to avoid slack water and Bennett et al. (1993) found sturgeon moving upstream towards higher velocities from spring through fall in Lower Granite Reservoir, Washington. White sturgeon occupy waters from 2 to 14 m deep with a preference for deeper waters during winter (Haynes et al. 1978; Lukens 1985). Coon et al. (1977) found that sturgeon often ventured into shallow waters, although deeper pools (> 7 m) were near and were occupied during daylight hours. Sampling of white sturgeon in Lower Granite Reservoir showed the majority were collected in depths > 10 m with an average depth of 18 m (Bennett et al. 1993). White sturgeon spawn over rocky substrate with swift velocities typically during May and June (Scott and Crossman 1973).

Suitable sturgeon habitat is considered to contain velocities from 3 to 70 cm/s with depths > 10 m for refuges during daylight hours. Suitable white sturgeon summer habitat in the Pend Oreille River includes about 120 ha (3.1%) (Figure 46). Winter habitat requirements for white sturgeon are similar to summer requirements, although they tend to remain in deeper waters. Suitable winter habitat for white sturgeon would include about 371 ha (9.6%) of the Pend Oreille River (Figure 47). Assuming velocities in spawning habitat are > 50 cm/s with cobble substrate, about 25 ha (0.6%) of the Pend Oreille River, Idaho is considered good spawning habitat for white sturgeon (Figure 48).

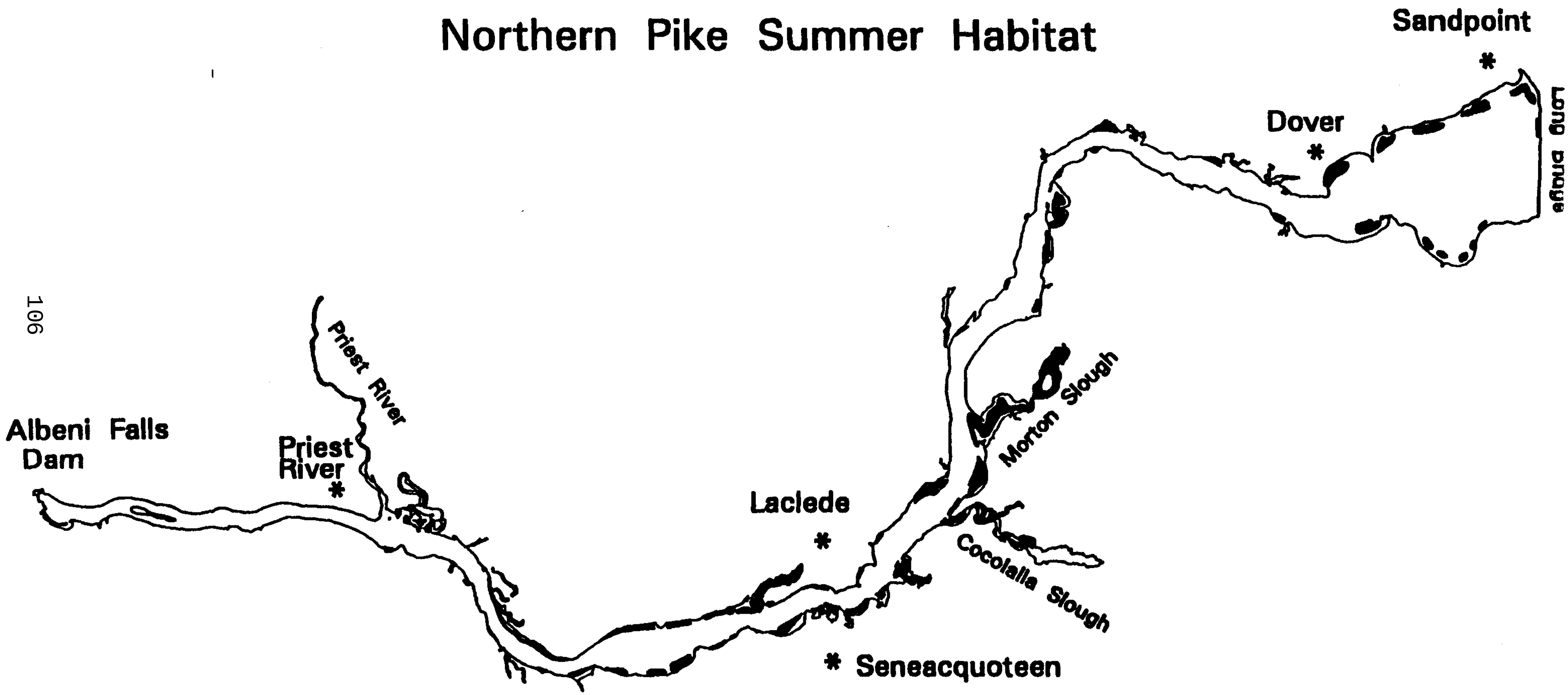


Figure 44. Suitable northern pike habitat during highpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

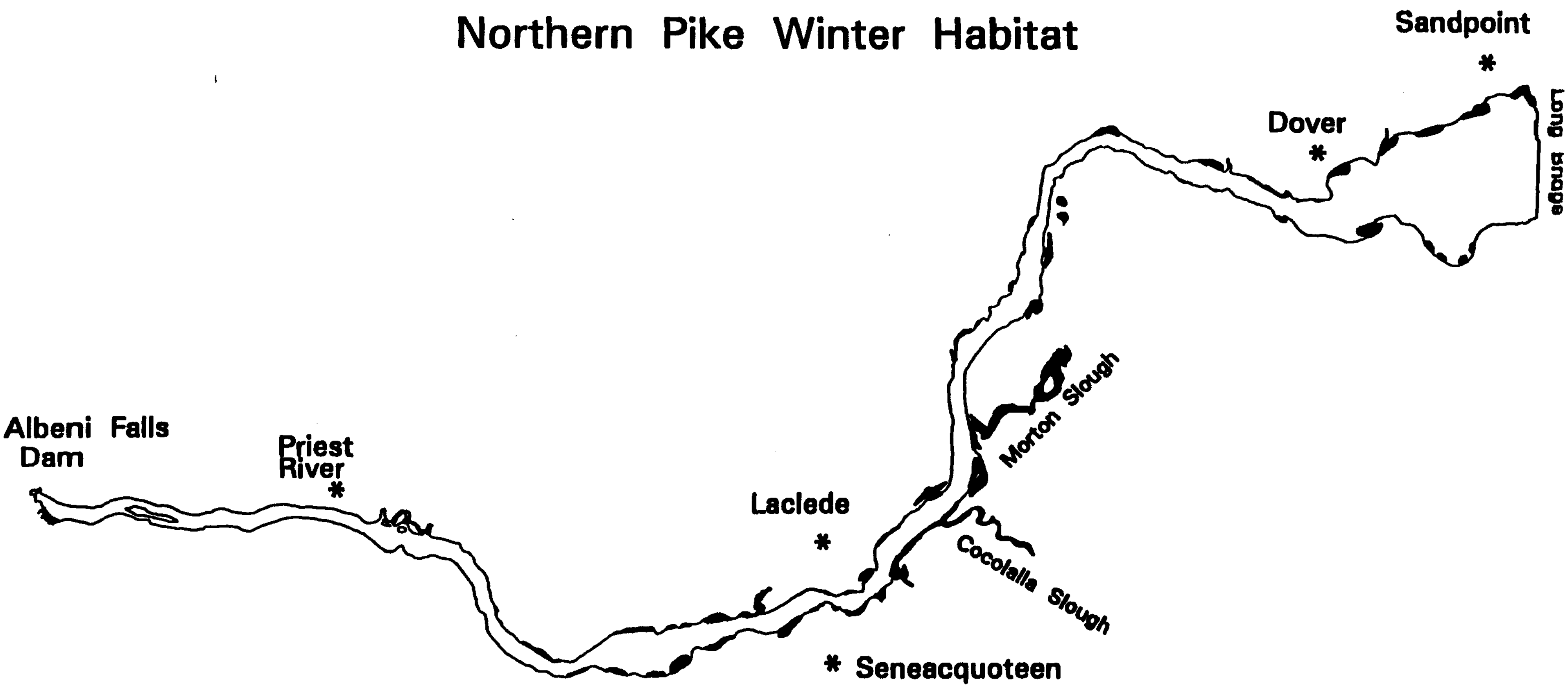


Figure 45. Suitable northern pike habitat during lowpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

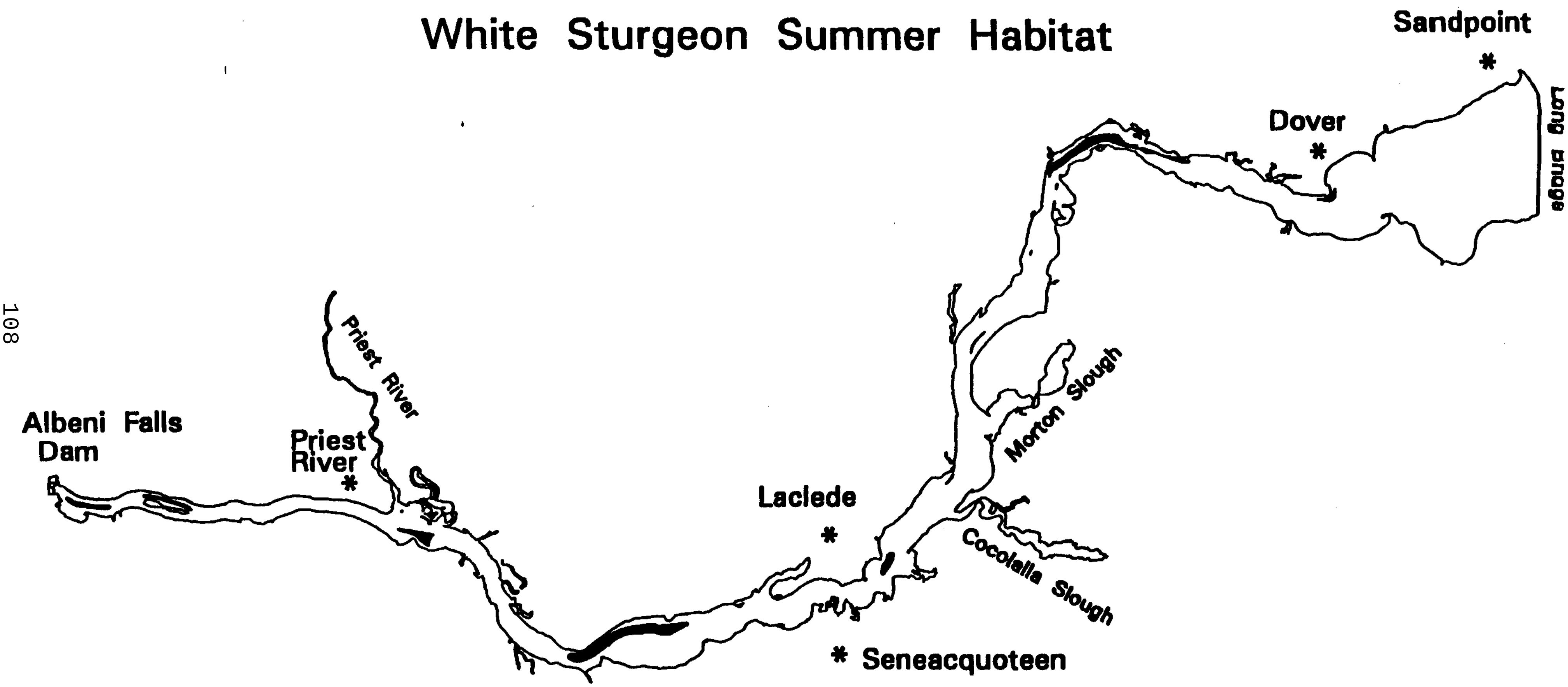


Figure 46. Suitable white sturgeon habitat during highpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

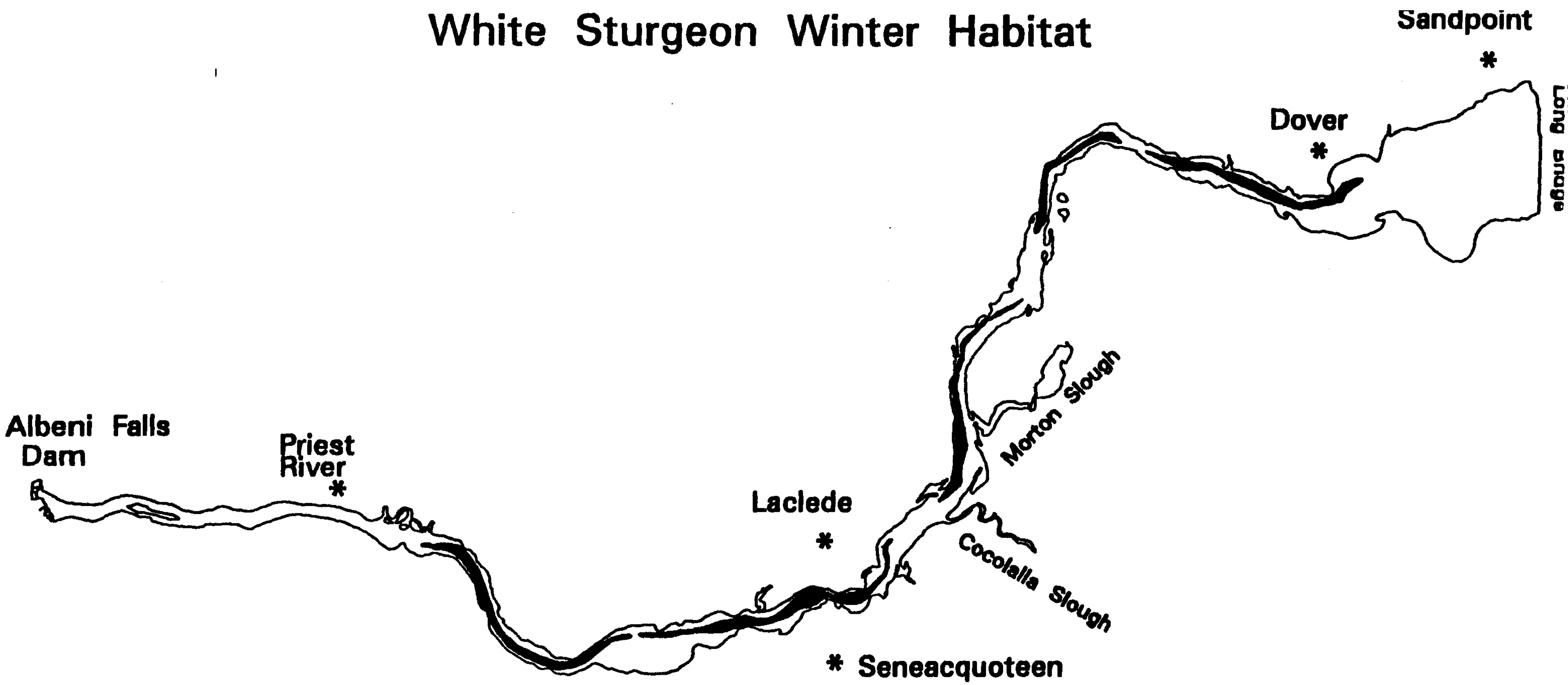


Figure 47. Suitable white sturgeon habitat during lowpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

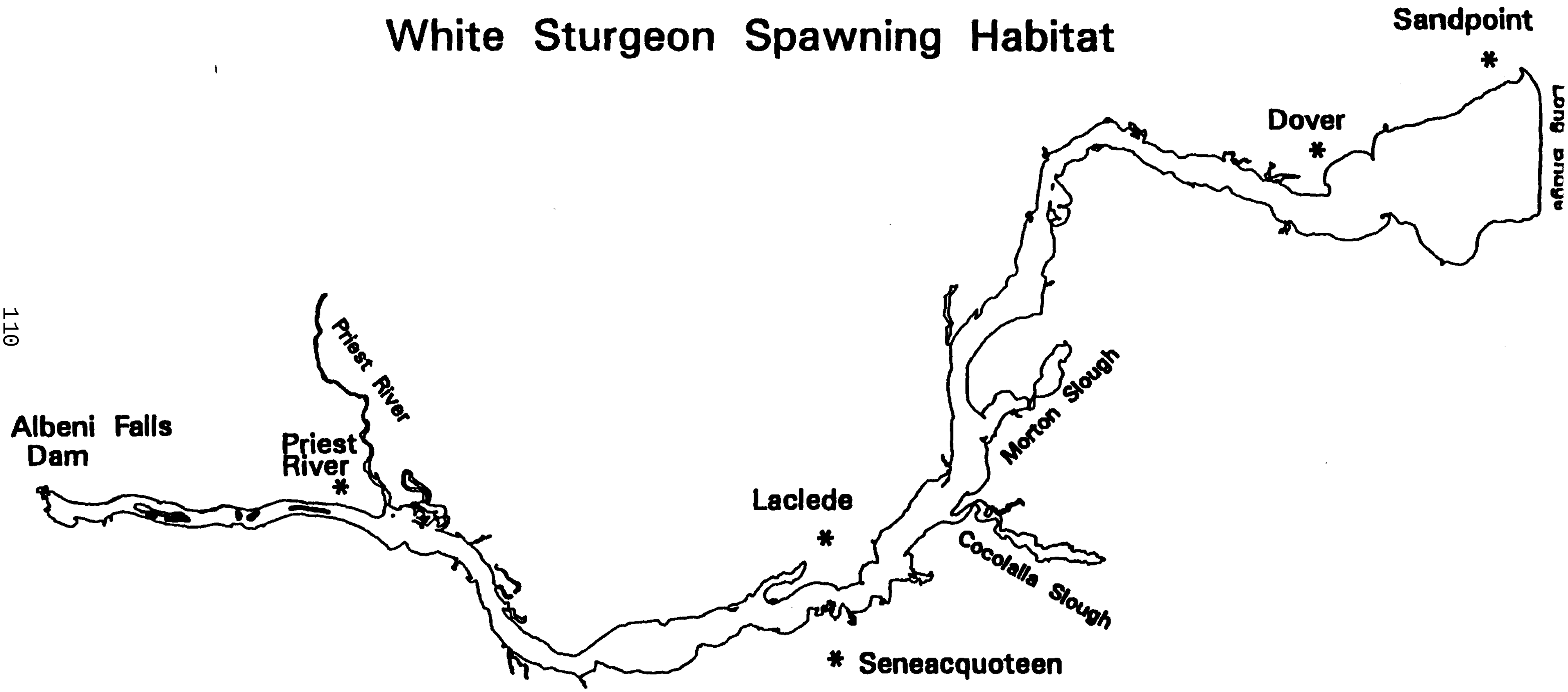


Figure 48. Suitable white sturgeon spawning habitat on Pend Oreille River, Idaho. Black shading represents suitable habitat.

Cochnauer (1983) found that contents of white sturgeon stomachs sampled in the upper Snake River were dominated by crayfish, whereas in the lower Snake River they were dominated by chironomids. Others have found fish to be the dominate food source for sturgeon (Scott and Crossman 1973). White sturgeon will generally feed on whatever is available (Scott and Crossman 1973; Coon et al. 1977; Cochnauer 1983). Chironomids are the dominant benthic invertebrate, by both numbers and biomass, in the Pend Oreille River and therefore adequate forage for white sturgeon would be available.

Channel Catfish

Scott and Crossman (1973) indicate channel catfish occupy waters with sand, gravel and cobble bottoms, although high densities of channel catfish are found in the Mississippi River where siltation is common (Pitlo 1992). Channel catfish are also successfully raised in farm ponds with clay bottoms (Tucker and Robinson 1990). During daylight hours channel catfish occupy deep holes or are found under rocks and logs, and then they move at night into shallow waters to feed (Scott and Crossman 1973). During winter, channel catfish congregate in the main river channel in low velocity areas (velocity undefined) positioned behind rubble, bolder, or some type of structure (Sheehan et al. 1990). Preferred spawning temperatures are 24 to 27°C (Carlander 1969; Scott and Crossman 1973). However, Bratovitch (1985) found channel catfish to spawn in waters ranging from 18 to 22°C in the lower Snake River reservoirs. Channel catfish require secluded semidark waters and construct nests for spawning in holes, undercut banks, log jams, or rocks (Carlander 1969; Scott and Crossman 1973; Bratovitch 1985).

No attempts were made to map summer habitat use of channel catfish because it is extremely variable. Channel catfish have been found in habitats with rock to clay substrates during summer, thus we assume adequate summer habitat is available in Pend Oreille River, Idaho. Overwintering habitat consists of cobble or bolder substrates where channel catfish can avoid winter currents with slow velocities < 10 cm/s. Habitat satisfying overwinter requirements covers 27 ha (0.9%) of the surface area of the Pend Oreille River (Figure 49).

Based on the Snake River studies, spawning of channel catfish would occur in July and August in the Pend Oreille River (Bratovich 1985). Spawning habitat for channel catfish in the Pend Oreille River would consist of stumps or rocks where secluded nests could be made. Approximately 16 km (10%) of shoreline is considered suitable spawning habitat for channel catfish in Pend Oreille River (Figure 50).

Channel catfish feed on insects early in life and switch to molluscs, crayfish, plants and fish as they mature. Minnows and yellow perch dominate food items of channel catfish in Canada (Scott and Crossman 1973). Food habits of channel catfish are similar to many fishes of Pend Oreille River which flourish in this system.

Walleye

Potential success of introducing walleye into Pend Oreille River was evaluated using data from Bennett and McArthur (1990). Bennett and McArthur (1990) found a high probability for success in establishing a self-sustaining walleye population based on four variables: maximum depth, pH, area of system and date the system was impounded.

Systems with high success in introducing walleye had high maximum depths (> 15 mm), high pH (> 8.0), large areas (> 3,238 ha) and early dates of

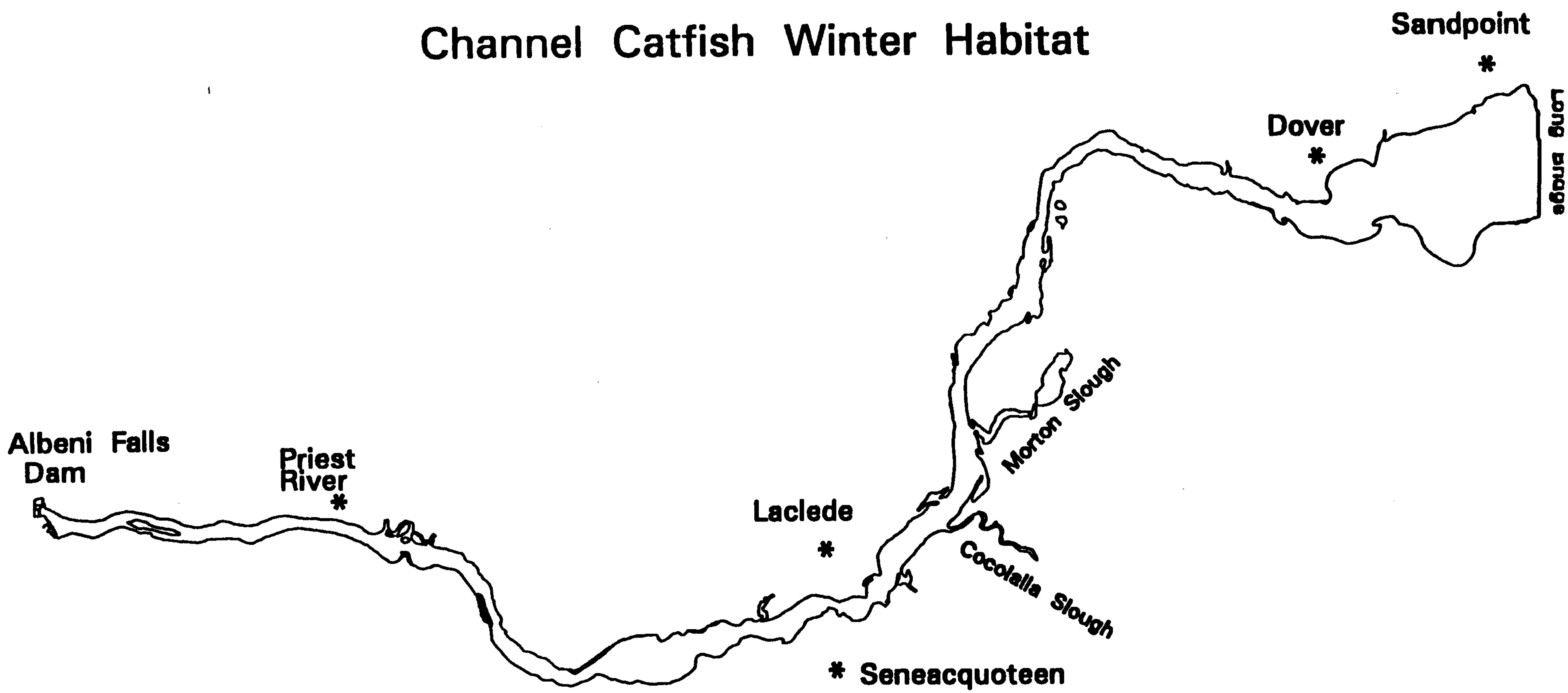


Figure 49. Suitable channel catfish habitat during lowpool on Pend Oreille River, Idaho. Black shading represents suitable habitat.

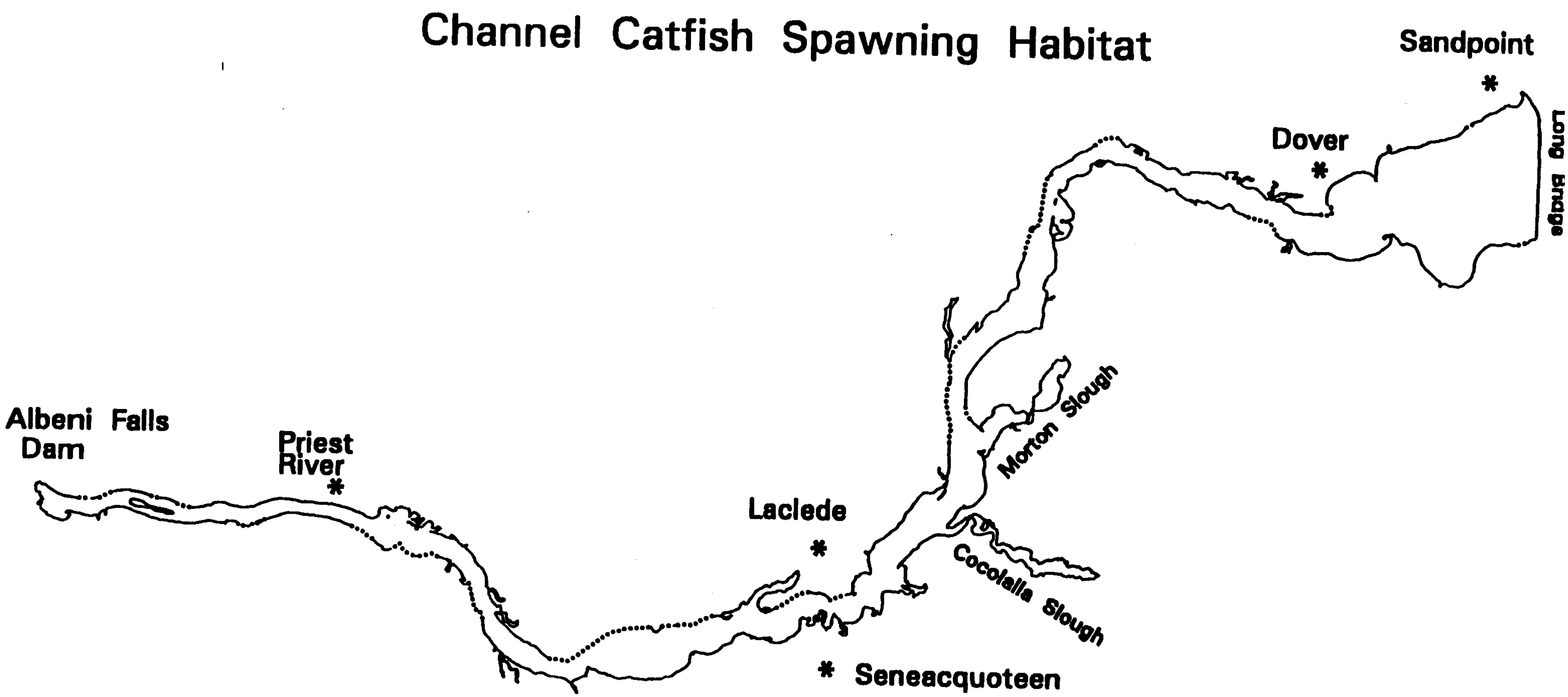


Figure 50. Shoreline spawning habitat available for channel catfish on Pend Oreille River, Idaho. Dotted shoreline represents good spawning habitat.

impoundment (< 1920). The Pend Oreille River, Idaho has a maximum depth of 48.5 m, an average pH of 8.2, an area of 3887 ha and was impounded during 1952. Using Bennett and McArthur's (1990) model for predicting the likelihood of success in establishing walleye in the Pend Oreille River, the probability for success is 61%.

DISCUSSION

Smallmouth Bass

Spawning habitat for smallmouth bass appears to be abundant, as 26% of the shoreline in Pend Oreille River has qualities suitable for spawning. However, summer and winter habitat for smallmouth bass covers 2.9 and 2.3% of the surface area. Limited areas of rocky substrate are responsible for low quantities of suitable habitat for smallmouth bass in the Pend Oreille River, Idaho. Coble (1975) found that in silty rivers smallmouth base populations were only located along rock outcrops. Most rocky substrate in Pend Oreille River is located along roads or railroad tracks with rip rap. Impoundment of Pend Oreille River (slower water velocities) and the annual drawdown has caused increased bank erosion and sedimentation which has resulted in the siltation of most natural rocky areas. If smallmouth bass were stocked in Pend Oreille River, Idaho, small populations would likely occur along the rocky shorelines. Although rocky habitat may cover < 3% of the surface area, 9% of the shoreline is considered to be rocky during highpool and 6.6% during lowpool. Overwintering habitat for smallmouth bass appears to be limited. Regardless, angling opportunities could likely be increased especially for shoreline fishermen in the Pend Oreille River, Idaho.

Northern Pike

Summer and winter habitat appears adequate for northern pike to provide a substantial fishery, however spawning habitat is not available. Shallow vegetated waters needed for spawning do not exist in the Pend Oreille River during April-May, the projected time of spawning. Annual drawdown dewaters vegetation and exposes it to freezing and desiccation. When water levels rise during early April, unvegetated ground is covered and water levels do not flood terrestrial grasses. In Kansas, natural recruitment of northern pike has generally not occurred in reservoirs as spawning habitat is not available (Groen and Schroeder 1978). Limited spawning success has only occurred in these reservoirs when water levels rose into previously unflooded grasslands. However, grasses were not adequately re-established in the short growing season after drawdown, thus spawning success was not found the following year (Groen and Schroeder 1978). Nelson (1978) found northern pike reproduction was poor in Lake Oahe, South Dakota after the reservoir was filled but terrestrial vegetation was not flooded. When spawning did occur in Lake Oahe, silt caused high mortality of pike eggs. Based on this cursory analysis, a northern pike population in the Pend Oreille River would not be self-sustaining under the current water management program.

White Sturgeon

Although many pools > 10 m exist in the Pend Oreille River, velocities in these pool are often less than what sturgeon prefer (3-70 cm/s). During summer, no pools > 10 m in depth had velocities > 12 cm/s. These velocities are similar to the lower portion of Lower Granite Reservoir where most sturgeon densities are low (Bennett et al. 1993). Lower Granite Reservoir appears to provide rearing habitat for juvenile sturgeon (Bennett et al. 1993), but spawning has not been found.

If sturgeon became mature in the Pend Oreille River, suitable spawning habitat would probably be limited as < 1% of the river has rocky bottoms with swift velocities. Areas that meet these conditions are < 4 km from Albeni Falls Dam. Juvenile sturgeon may migrate over Albeni Falls Dam as they migrate down river (Coon et al. 1977). Sturgeon do not appear to be suitable for introduction into Pend Oreille River, Idaho as rearing and spawning habitat are limited.

Channel Catfish

Channel catfish prosper in systems with silty to rocky bottoms. This indicates summer habitat conditions in Pend Oreille River should be suitable for channel catfish, although lower water temperatures would limit growth. Temperatures suitable for spawning (> 18°C) would occur in July and August. During this time, water levels are high and stable which would allow flooded stumps and rip rap to be utilized (10% of shoreline). Channel catfish have similar feeding habits as other fishes in the system that have high relative weights which indicates that food would not be a problem for channel catfish.

Overwintering habitat for channel catfish may be limited in the Pend Oreille River. Assuming channel catfish require low velocities with cobble and bolder substrate, these characteristics are found in < 1% of Pend Oreille River, Idaho. Based on this cursory review, habitat in the Pend Oreille River is currently not ideally suited to the habitat requirements of channel catfish.

Walleye

We estimated a probability of 61% success in establishing a self-reproducing population of walleye in the Pend Oreille River, Idaho. Walleye tolerate flowing waters of 0°C, thus overwinter survival would not be a problem (Sheehan et al. 1990). Walleye spawn in areas of rock and cobble often below dams, but they are known to use rock to coarse gravel shoals in lakes (Scott and Crossman 1973; Nelson 1978; Paragamian 1989). Walleye successfully spawn over wave washed shorelines of heavier, larger substrate where smaller particles are removed, leaving heavier larger substrate (Nelson 1978). Large gravel to bolder substrates are found in 8% of Pend Oreille River, although large areas for spawning are not needed for successful populations. Abundant food sources are available in Pend Oreille River since northern squawfish is the major predator in the system. Although the probability of establishing walleye in Pend Oreille River is > 50%, walleye have been stocked into Box Canyon Reservoir, immediately downstream of Albeni Falls Dam, and they did not become established.

Also, walleye in the Pend Oreille River, Idaho would have access to Pend Oreille Lake. Limited forage abundance in the lake and kokanee, the principal prey species, may not be able to withstand additional predation pressure as kamloops Oncorhvnchus mvkiss and bull trout already forage on kokanee. Because of the potential for walleye to migrate into Pend Oreille Lake and their potential for intense predation, we do not recommend walleye stocking in the Pend Oreille River, Idaho.

GENERAL DISCUSSION

Our findings indicate the Pend Oreille River is dominated by yellow perch, peamouth and northern squawfish which account for about 60% of the fish community. Game fishes are not abundant in the Pend Oreille River. Summer temperatures are considered too warm for most salmonids, and cold winters coupled with drawdown limits centrarchid fish numbers.

Improvements in the quality of the salmonid fishery may be difficult as temperatures are probably limiting their numbers. However, these temperatures may be suitable for brown trout as those sampled throughout the summer exhibited good body condition. Recruitment seems to be limiting brown trout numbers as spawning habitat seems to be restricted to Hoodoo Creek and possibly highly limited areas at the mouth of Priest River. Prespawning brown trout were sampled near the mouth of Priest River during late October.

Although stocking catchable trout was suspended in 1985, introductions of brown trout into tributaries to establish adfluvial runs, such as Hoodoo Creek, may have potential. Unfortunately, tributaries of Pend Oreille River may be too small during fall to provide adequate spawning habitat for brown trout.

Improvements in the centrarchid populations (largemouth bass, black crappie and pumpkinseed) could occur with changes in water management. Our data suggests that overwintering habitat is limiting centrarchid numbers, however, spawning success appears high and summer habitat is abundant. Higher water levels during the winter would probably result in higher survival and increased abundance of centrarchid fishes.

Introductions of fishes may provide another alternative to improving the fishery in the Pend Oreille River. Introductions of northern pike and white sturgeon would likely not be successful. Smallmouth bass could probably be established along rocky shorelines, although they would not contribute greatly to the fishery as suitable habitat, rocky substrate, is found in < 3% of the Pend Oreille River. Channel catfish might be suitable to the Pend Oreille River, however winter habitat and less than optimum summer temperatures may limit their potential.

Walleye could probably be successfully established in the Pend Oreille River, although we do not recommend their introduction because of potential adverde affects on fisheries in Pend Oreille Lake. Our analysis show that modifications in water management and brown trout introductions probably afford the highest potential to improve sport fishing in the Pend Oreille River, Idaho.

SUMMARY

1. Physico-chemical properties collected from the Pend Oreille River, Idaho reveal daily average temperatures range from 0 to 24.5°C. Phosphorous, pH and transparency readings classify Pend Oreille River as meso-oligotrophic. The Pend Oreille River is dominated by silt and sand (86%) and velocities generally remain < 30 cm/s.

2. Average zooplankton densities were approximately 40 organisms/L and the average sizes were > 8 mm. Chironomids and oligochaetes dominated benthos samples by number, whereas chironomids and ephemerids dominated by weight. The lowest densities of benthos were found in sloughs which may indicate negative effects of the drawdown. Submerged aquatic macrophytes cover 14% of the Pend Oreille River. Distribution of aquatic macrophytes into waters < 3 m deep may be limited by drawdown.

3. Over 50,000 fish representing 24 species were sampled during 1991 and 1992. Yellow perch, peamouth and northern squawfish dominated the fish community. Trout species represented < 2% of the catch during 1991 and 1992. Largemouth bass represented 1.2% during 1991 and 3.3% during 1992, while black crappie represented 1.2% for both 1991 and 1992.

4. Largemouth bass and black crappie were most abundant in sloughs with habitat conditions of zero velocities, silty bottoms and vegetation. Rainbow and cutthroat trout selected littoral habitats along the main river channel where average substrate size was < 15 mm.

5. Food habits of yellow perch, peamouth and northern squawfish showed limited diet overlap. Yellow perch consumed insects, fish and zooplankton. Northern squawfish fed predominantly on fish and crayfish, while peamouth fed almost exclusively on insects. Largemouth bass, black crappie and brown trout had high diet overlaps with yellow perch > 200 mm and northern squawfish. These fish all consumed prey fishes. As prey fishes in Pend Oreille River are abundant, diet overlap for food is not considered important within these species.

6. Growth of yellow perch in Pend Oreille River is considered typical for northern Idaho. Largemouth bass, black crappie and brown trout experienced higher growth rates than other stocks in the northwest.

7. Annual mortalities of yellow perch, largemouth bass and black crappie all exceeded 60%. High mortalities are probably a result of severe winters coupled with limited overwintering habitat as a result of the 3.5 m drawdown.

8. Comparison of catch rates of fishes between Pend Oreille River, Idaho and Box Canyon Reservoir, Washington indicates drawdown affects the abundance of largemouth bass, black crappie and pumpkinseed. Summer habitat in the Pend Oreille River, Idaho for centrarchids is adequate, however, overwintering habitat is 4% of summer habitat. If drawdown were limited to 2 m, overwintering habitat would increase 7.5 fold.

9. Introductions of fishes may be an alternative to improving the fishery in the Pend Oreille River, Idaho. Habitat is not suitable for white sturgeon and northern pike. Smallmouth bass could produce a limited fishery along the rocky shorelines. Channel catfish may be suitable to Pend Oreille River, although optimum temperatures for growth do not occur and overwinter habitat seems limited. Walleye introductions would probably be successful in establishing a self-sustaining fishery, although a high potential for immigration to Pend Oreille Lake should make this introduction nonsensical.

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Appendix Table 1. Characteristics of strata sampled in the Pend Oreille River, Idaho during 1991 and 1992.

Strata	Area description	Length	No. sites Sampled
1 littoral	Along main river channel avg substrate size < 15 mm	75.5 km (shoreline)	3
2 littoral	Along main river channel avg substrate size > 15 mm	21.1 km (shoreline)	2
3 littoral	Off-river channel (sloughs) avg substrate size < 4 mm	27.0 km (shoreline)	2
4 pelagic	Avg width = 0.40 km avg depth = 6.36 m	8.9 km (river)	2
5 pelagic	Avg width = 0.75 km avg depth = 8.15 m	30.6 km (river)	2
6 pelagic	Avg width = 2.25 km avg depth = 5.36 m	4.8 km (river)	2

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